

# The deep-sea Ophiuroidea of the North Atlantic Ocean

Gordon L. J. Paterson

Department of Zoology, British Museum (Natural History), London SW7 5BD



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## Synopsis

The North Atlantic deep-sea ophiuroid fauna, comprising of approximately 120 species, is revised for the first time. Proposals for the revision of the family Ophiacanthidae are made and four sub-families are erected. The present purely taxonomic treatment relies on a series of pictorial keys aimed at the non specialist.

## Introduction

The recent interest in deep-sea biology has highlighted the need for a taxonomic reappraisal in many animal groups. In all but a few our taxonomic knowledge is based on expedition reports dating back often more than 50 years. Such reports are not comprehensive, and may be difficult to obtain, so that identifications require a large library. With the modern emphasis in deep-sea studies on ecology, population biology and biological processes generally, good taxonomic information is essential.

The aim of this study is to revise the abyssal ophiuroids of the North Atlantic portraying the species likely to occur within this area so as to facilitate identification by the non specialist. Within the study area there are about 120 species including several new records for the North Atlantic.

The boundaries of the study area are more of convenience than purely zoogeographical, because of the paucity of material from certain regions. So the area is taken to be that south of the Shetland-Iceland-Greenland ridges as far as Cap Blanc in the eastern Atlantic and the Demerara Abyssal Plain in the west. This is approximately equivalent to the abyssal provinces C1 and C2 proposed by Menzies, George & Rowe (1973) or the 2B abyssal zones proposed by Vinogradova (1979).

The upper bathymetric limit is *c.* 1000 m, following the scheme proposed by Menzies, George & Rowe (1973). This corresponds to the Archibenthic Zone of Transition in the eastern Atlantic and to the Abyssal Province in the west. The Abyssal Province begins around 2000 m in the east. Since many ophiuroids are eurybathic these bathymetric limits are only guidelines. In some families species have been included from the upper slope in the event of overlapping bathymetric ranges. Also hydrographic factors may influence distributions: for example in the Rockall Trough the influence of Norwegian Sea overflow water is thought to extend upwards the distribution of certain species commonly associated with the lower abyssal zone (Gage *et al.*, 1983). It is also noticeable that pan Atlantic species have a shallower upper bathymetric limit in the west than in the east, possibly due to the effects of the Western Boundary Current.

This paper is based on extensive collections made by three institutions: The Centre Océanologique de Bretagne—Biogas investigations in the Bay of Biscay, Biovema in the Vema Fracture Zone, Demeraby in the Demerara Abyssal Plain and the INCAL cruise in conjunction with the IOS and SMBA in the NE Atlantic; the Institute of Oceanographic Sciences—*Discovery* Investigations off North Africa and in the Porcupine Seabight; the Scottish Marine Biological Association's investigations in the Rockall Trough. Type specimens of most species were also examined together with material in the collections of the BMNH. A list of the specimens studied, together with their register numbers, and a photograph of each species have been deposited in the Echinoderm Section, BMNH.

## Biology

Our knowledge of life histories of most deep-sea ophiuroids is poor (see Tyler, 1980 for a review) although in recent years there have been several accounts of the reproductive biology of the more common species (Schoener 1968, 1972; Tyler & Gage 1979, 1980, 1982; Gage & Tyler, 1981, 1982) together with some work on the post-larval stages (Schoener 1967, 1969; Gage & Tyler 1981). Accordingly this study is limited to taxonomic aspects.

Little has been done on the ecology of deep-sea species apart from observations on certain conspicuous species such as *Ophiomusium lymani* in the course of more general studies (Barham *et al.* 1967; Rowe, 1971; Menzies, George & Rowe, 1973; Grassle *et al.* 1975 and Haedrich *et al.* 1975). Detailed treatment of the ophiuroid fauna of the Bay of Biscay has been carried out by Paterson, Lambshead & Sibuet (1985) and Gage *et al.* (1983) have discussed aspects of ophiuroid distribution in the Rockall Trough.

There are little data on the nutrition of abyssal ophiuroids (Litvinova & Sokolova 1971, Litvinova, 1980) or of their predators or parasites.

## Taxonomic keys

*Review.* Traditionally most taxonomic works employed dichotomous keys for identification of the taxa involved. There is, however, a growing feeling amongst users that these are far from adequate in aiding quick accurate identifications and can be misleading when taxa new to the area or to science are being identified.

In recent years there have been several attempts to produce new kinds of keys. A key in this context is taken in its widest definition—an artificial system for identifying animals or plants; the



term key should not be restricted to the dichotomous kind. An improvement to the basic dichotomous key is the illustration of the individual characters in the couplet: for examples see Bayer (1961) or Grasshoff (1973, 1977). Keys produced by the Field Studies Council under their AIDGAP scheme are also of this kind and have the advantage of being tested before they are published.

This sort of key is taken to an ultimate conclusion in the keys associated with the San Francisco Bay project. Instead of couplets the information is presented in the form of a pictorial flow diagram. Light (1976) highlighted the problems associated with specialist dichotomous keys and proposed this pictorial alternative.

The tabular key has also been developed as an alternative to the traditional kind. Such keys were pioneered by Newel (1953) for mites. Here a series of characters represented by letters or symbols are presented for comparison, usually arranged in tabular form. The specimen for identification is examined with regard to a series of relevant characters and the resulting list compared with the table. The advantage of this form of key is that several different characters are compared together so that if one or more is missing, closeness of fit to the list can be used to gain an identification. The other feature of these keys is that the actual characters which separate the species can easily be assessed; helping both to improve the key and assess the real difference between species. For examples of tabular keys, see Newel (1970), Monniot & Monniot (1972) on ascidians, Cherbonnier & Guille (1978) on ophiuroids, Doumenc (1979) on actinians, and A. M. Clark (1981) on asteroids.

Some workers have done away with the need to have keys to the symbols by including the phrase or picture in the body of the table (see Lamshead, 1981 and Paterson, Tyler & Gage, 1983).

For quick accurate identifications the most promising keys are totally pictorial. These have been sadly neglected by most taxonomists. Exceptions are Fische d'Identification du Zooplankton which also incorporates tabular textual keys, Russell's (1953) pictorial key to the hydromedusae and scyphomedusae, Zavodnick (1972) key to the amphiuroid ophiuroids and more recently Lamshead (1981) and Platt & Warwick (1983) keys to marine free-living nematodes. However, these are still in the minority (see also Cornelius, 1982).

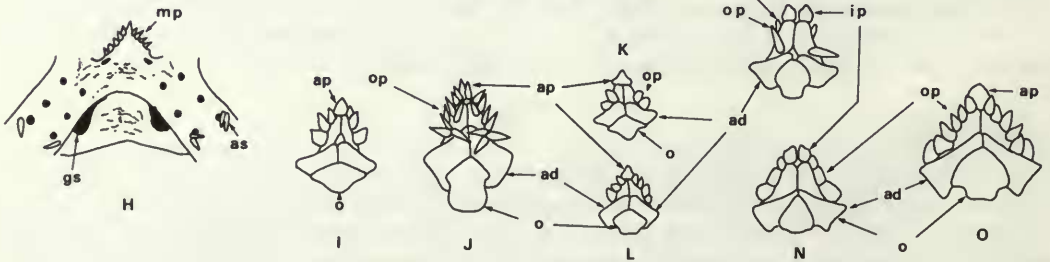
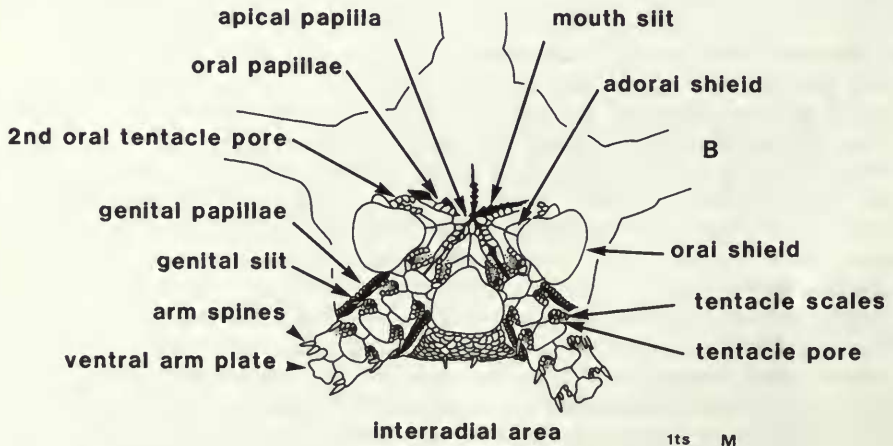
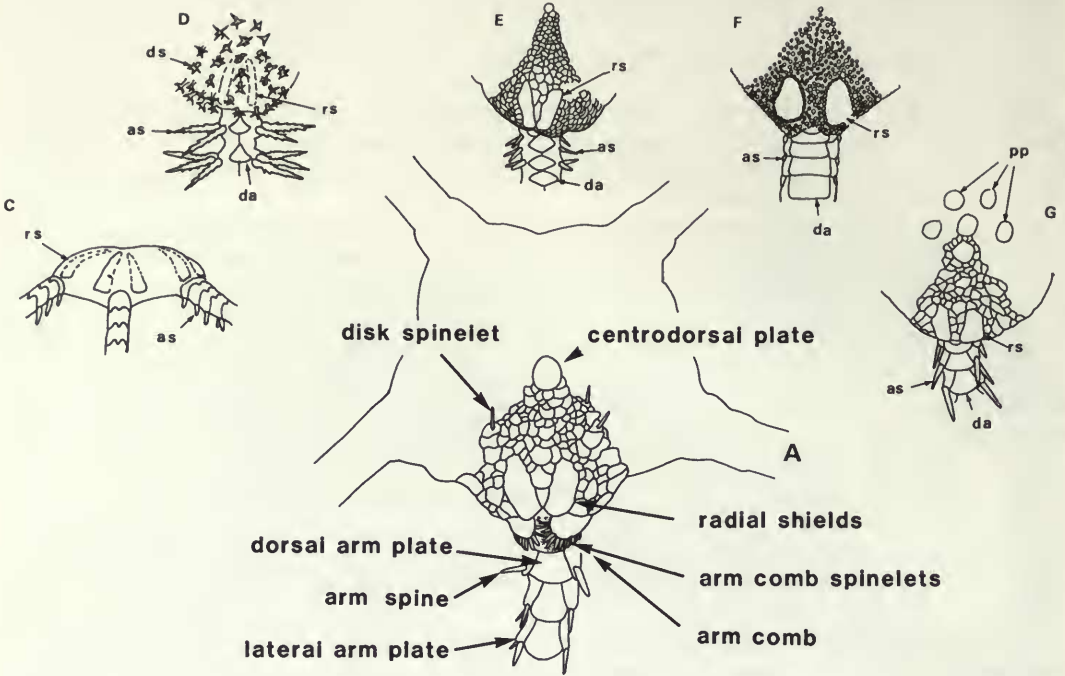
In the more popular field guides such keys have been common since the first popular guides were written by R. Tory Petersen. He arranged similar looking birds on the illustration with arrows to highlight important taxonomic features, a layout followed by most Collin's Field Guides. This easy use by non specialists is the great advantage of pictorial keys. Provided that there is some information on the basic anatomy and organisation of the animals being dealt with, it is possible to identify many animal groups without extensive knowledge of the group.

It is interesting to compare the use of pictorial aids to identification in other fields. The accurate identification of ships and aircraft during the recent world wars was of major importance. The emphasis was on good visual guides with courses on the methods used to identify these objects. Much of the experience learnt then applies equally to the biological sphere now. For example, it was found that the most effective way of comparing aircraft was to compare two aircraft at a time (C. H. Gibbs-Smith, 1942, *Aircraft Recognition*, 1(2)). This can easily be done with a pictorial key. In some examples it was thought necessary to highlight important distinguishing features with arrows or emphatic shading. This was suggested for guides for the recognition of ships from the air (G. Bijur, 1943). Again highlighting drawings, as in the Petersen field guides draws attention to particular features which should be present.

### Present treatment

Ophiuroids are particularly suitable for a pictorial treatment. Most of their taxonomic characters are evident in the external skeleton. So no special preparation is needed.

Basic ophiuroid morphology comprises a central disk and five (sometimes more) radiating arms; dorsally the disk is covered with calcite plates or thickened skin which may possess various spinelets or granules; ventrally there is a centrally placed mouth with angular interradial jaws. Most of the important taxonomic features are found on the ventral side particularly the



arrangement of the plates around the jaw (Fig. 1). The arms carry spines; in euryalid genera on the ventral part of the arm, while in the ophiurids they are carried laterally on the lateral arm plates. Along the ventral part of the arm the tube feet called tentacles arise in pairs, each tentacle emerging via a pore which is often armed with one or more scales (Fig. 1).

The pictorial keys presented apply to adult individuals only (disk diameter  $\geq 4$  mm). As far as possible species which are similar are grouped together. Drawings of each species were done using a Wild M-5 stereomicroscope with drawing tube. The orientation of the drawings is as shown in Figure 1. The ventral view comprises 2–3 of the 5 jaw angles—about half the disk area; while the dorsal view covers a wedge from the centre of the disk to the base of the arms. Where necessary the ventral view is supplemented with drawings of the disk armament, arm spines and lateral views of the arms. Drawings are not in scale, being made to a convenient and similar size, so *particular attention should be paid to the accompanying bar scales*.

The only special preparation needed is for euryalid species, the thickened skin covering the arm spines must be dissolved using bleach (sodium hypochlorite) or KOH. In most North Atlantic species these spines are not crucial to the identification, but are included to help confirmation.

Usually there is only one drawing per species but supplementary ones may be included to show excessive variation. Allowances should be made for some variation but the key characters highlighted by arrows, are unlikely to vary significantly. Particular characters are high-lighted by a touching arrow whereas important regions are indicated by an arrow slightly removed. The text should be consulted both to verify identifications and to check the range of variation.

Colour of species is not dealt with partly because the information is not available for many species and also because the range of variation has not been studied. Gage *et al.* (1983) have noted the colours of the species they collected and how it may aid the identification of certain species.

### Abbreviations

BMNH	British Museum (Natural History)
COB	Centre Oceanologique de Bretagne
DM	Dublin Museum
IOS	Institute of Oceanographic Sciences
MCZ	Museum of Comparative Zoology, Harvard
MNHN	Museum National d'Histoire Naturelle, Paris
MOM	Museum d'Océanographie de Monaco
MNMH	National Museum of Natural History, Washington DC
RSM	Royal Scottish Museum, Edinburgh
SAM	South African Musuem, Cape Town
SMBA	Scottish Marine Biological Association
ZMC	Zoologisk Museum, Copenhagen
ZSM	Zoologische Staatssammlung München
AT	Aggassis Trawl
CP	Beam Trawl (Chalut a perche)
DS	Epibenthic sledge (Drague Sanders)
ES	Epibenthic Sledge

For details of the BIOGAS station localities see Laubier & Sibuet (1977).

BIOGAS stations 1–4 are in the North of the Bay of Biscay 5 & 6 are in the South.

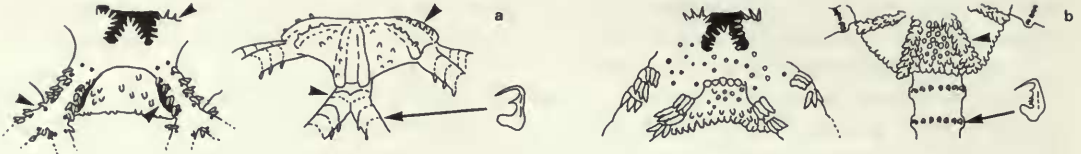
**Fig. 1** Illustrated glossary of morphological terms used in this study. A–dorsal, B–ventral view of *Ophiura ljunghmani* illustrating the important features. C–O shows the range of variation of these features in the main families; C–G variation of the disk and arm morphology of: C–euryalids, D–ophiacanthids, E–amphiurids, F–ophiodermatids, G–ophiochitonids. H–O variation in jaw morphology of: H–euryalids; I–J the range of morphology within the Ophiacanthidae, I–*Ophiacantha*, J–*Ophiocamax*; K–L the range within the Ophiactidae, K–*Ophiactis*, L–*Histampica*; M–N the range within the Amphiuridae, M–*Amphiura*, N–*Amphioplus*; O–ophiochitonids. Abbreviations: a.d.–adoral shield; a.p.–apical papilla; a.s.–arm spine; d.a.–dorsal arm plate; d.s.–disk spinelets; g.s.–genital slit; i.p.–infradental papillae; m.p.–mouth papillae; o–oral shield; o.p.–oral papillae; p.p.–primary radial plates; r.s.–radial shields; 1t.s.–first oral tentacle scale.



## KEY TO FAMILIES

## EURYALAE

## GORGONOCEPHALIDAE



## ASTERONYCHIDAE



## ASTEROSCHEMATIDAE



Fig. 2 Key to the Families. Gorgonocephalidae—(a) *Gorgonocephalus*, (b) *Astrochele*. Asteronychidae—(a) *Asteronyx*, (b) *Astrodia*. Asteroschematidae—(a) *Asteroschema*, (b) *Ophiocreas*.

## Taxonomic section

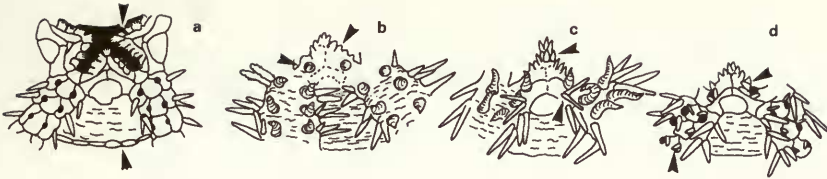
## EURYALAE Müller &amp; Troschel, 1842

## GORGONOCEPHALIDAE Ljungman 1867 emended Mortensen 1933b

This family is characterised by a large disk often covered with granules, spinelets or sometimes with thickened skin; the bar shaped radial shields extending almost to the middle of the disk; the papillae on the jaw usually spine like; the arms may be branched or simple, covered with granules and distally with bands of minute hooks. There are two genera represented in the abyssal North Atlantic: *Gorgonocephalus* Leach, 1815 which has branching arms and *Astrochele* Verrill, 1878 which has simple arms. *Astrochele* is commonly found clinging to gorgonians, corals, etc.

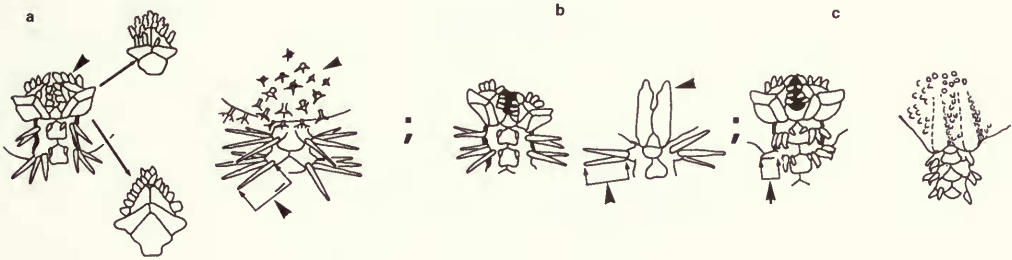
## OPHIURAE

## OPHIOMYXIDAE



## OPHIACANTHIDAE

## OPHIACANTHINAE



## OPHIOTOMINAE

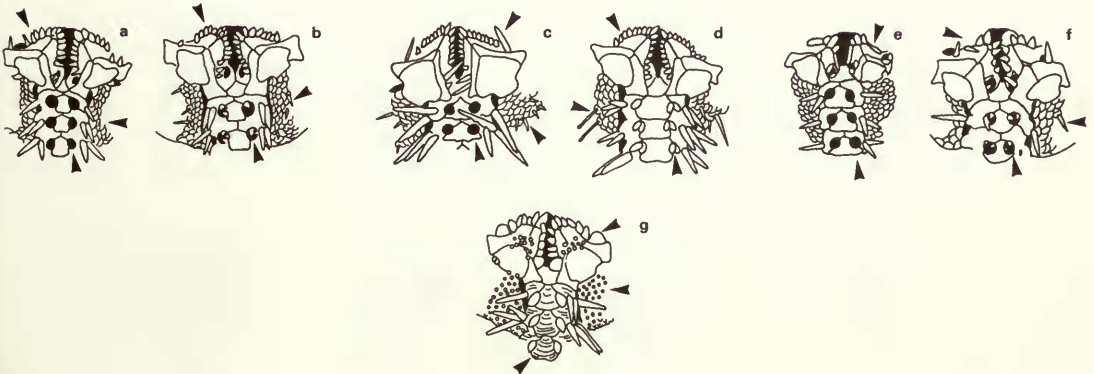
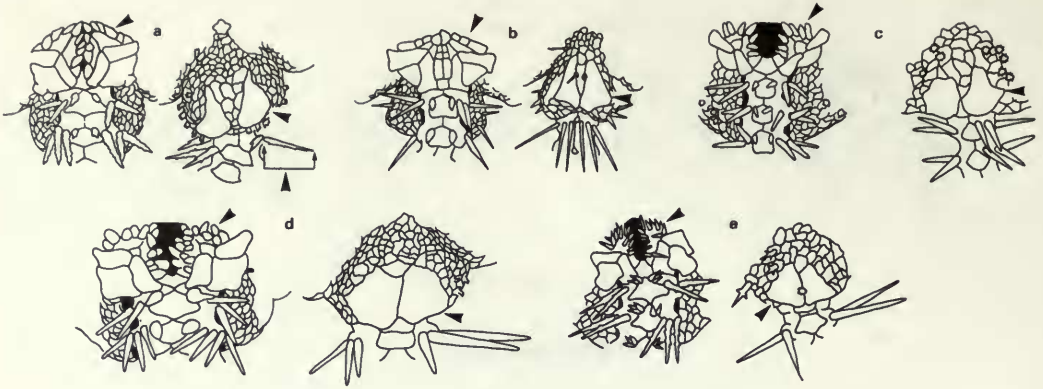
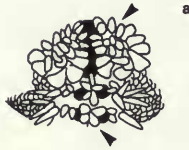


Fig. 3 Key to the Families cont. Ophiomyxidae—(a) *Ophiomyxa*, (b) *Ophiophrixus*, (c & d) *Ophioscolex*. Ophiacanthinae—(a) *Ophiacantha*, showing extremes of range, (b) *Ophiacanthella*, (c) *Ophiolebes*. Ophiotominae—(a) *Ophiotoma*, (b) *Ophiotrema*, (c) *Ophioprium*, (d) *Ophiopristis*, (e) *Ophiocymbium*, (f) *Ophiomedeia*, (g) *Ophiolimna*.

## OPHIOLINTHACINAE



## OPHIOHELINAE



## OPHIACTIDAE

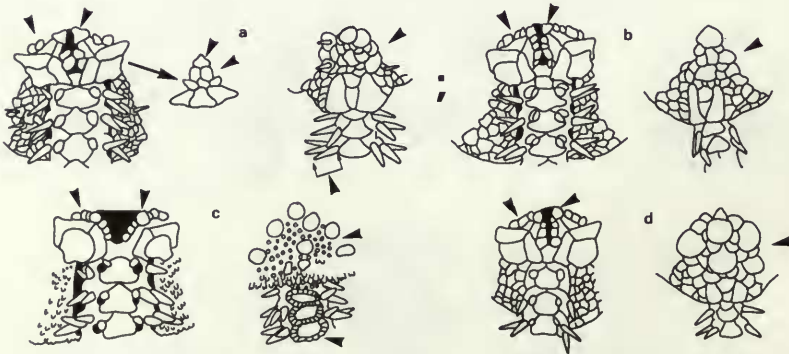
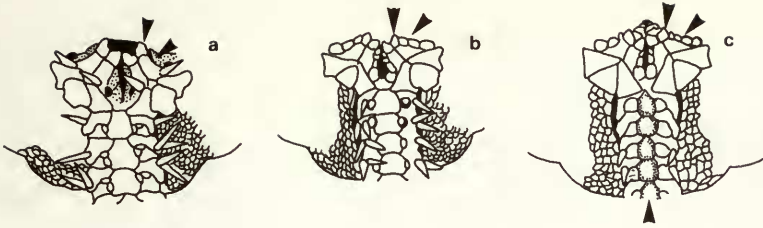


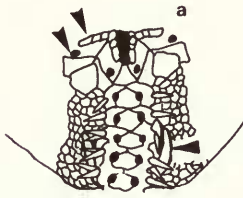
Fig. 4 Key to the Families cont. Ophiolinthacinae—(a) *Ophiolinthaca*, (b) *Ophiothamnus*, (c) *Ophiomitrella*, (d) *Ophiomitra*, (e) *Ophiocamax*. Ophiohelinae—(a) *Ophiomyces*. Ophiactidae—(a) *Ophiactis*, (b) *Histampica*, (c) *Ophiopholis*, (d) *Ophiopus*.



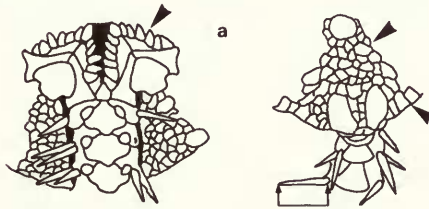
## AMPHIURIDAE



## AMPHILEPIDINAE



## OPHIOCHITONIDAE



## OPHIODERMATIDAE

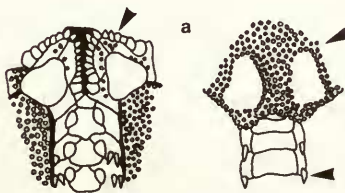
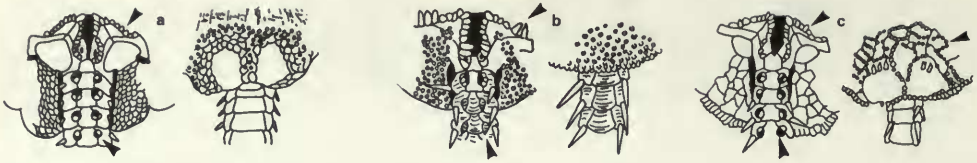


Fig. 5 Key to the Families cont. Amphiuroidae—(a) *Amphiura*, (b) & (c) *Amphioplus*. Amphilepidinae—(a) *Amphilepis*. Ophiochitonidae—(a) *Ophiochiton*. Ophiodermatidae—(a) *Bathypectinura*.

## OPHIURIDAE

## OPHIOLEUCINAE



## OPHIURINAE

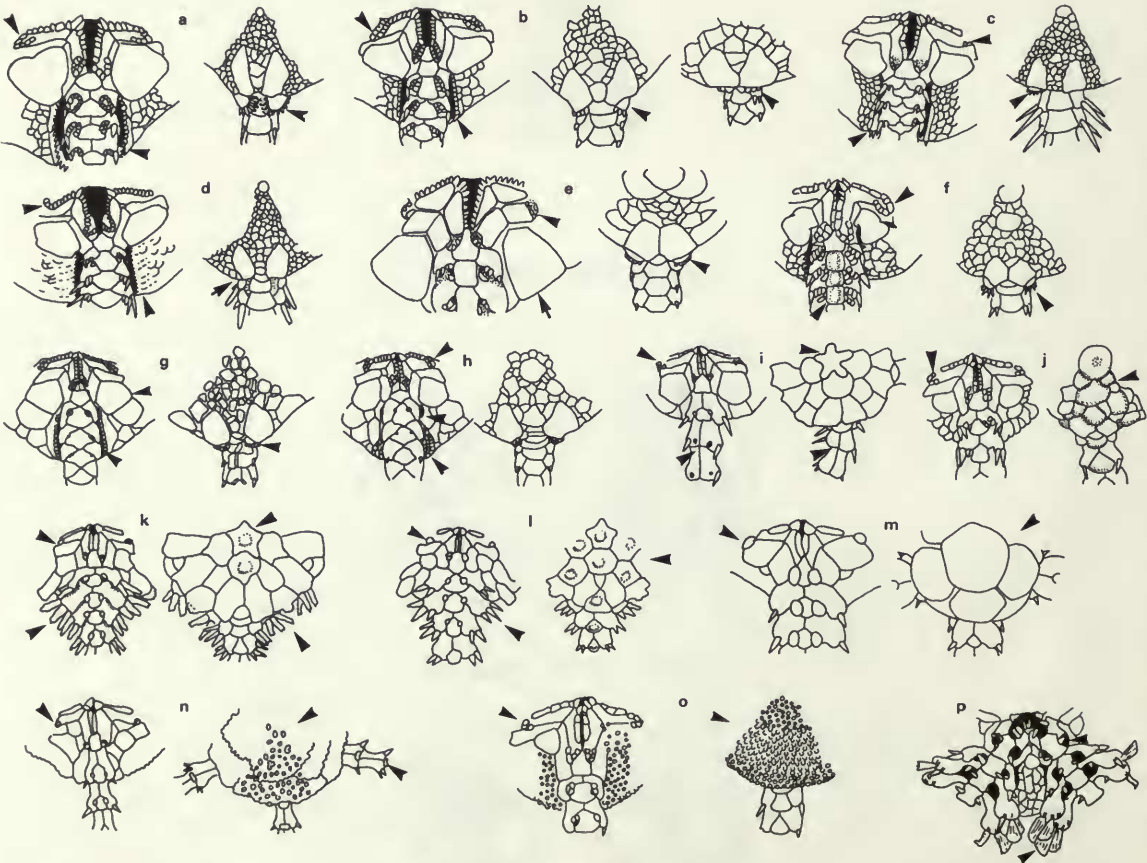


Fig. 6 Key to the Families cont. Ophioleucinae—(a) *Ophiernus*, (b) *Ophiostriatus*, (c) *Ophioleuce*. Ophiurinae—(a) & (b) *Ophiura*, (c) *Ophiocten*, (d) *Ophiopleura*, (e) *Amphiophiura*, (f) *Stegophiura*, (g) *Homophiura*, (h) *Ophiurolepis*, (i) *Anthophiura*, (j) *Ophiotjalpa*, (k) *Ophiophycis*, (l) *Ophiomisidium*, (m) *Ophiotypa*, (n) *Perlophiura*, (o) *Uriopha*, (p) *Ophiambix*.

## OPHIOLEPIDINAE

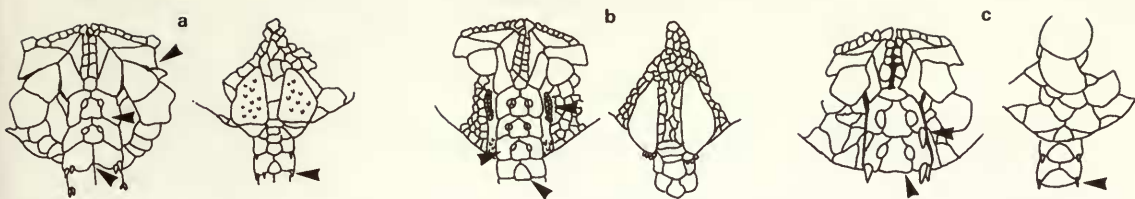


Fig. 7 Key to the Families cont. Ophiolepidinae—(a) *Ophiomusium*, (b) *Ophiosphalma*, (c) *Ophiozonella*.

*Gorgonocephalus caputmedusae* (Linnaeus, 1758)

Fig. 8

*Asterias caputmedusae* Linnaeus, 1758: 663.

*Gorgonocephalus caputmedusae*: Leach, 1815: 51; Mortensen, 1924: 13–16; 1927: 162–163; Blacker, 1957: 46–47; Gage *et al.* 1983: 288.

*Astrophyton linckii* Müller & Troschel, 1842: 122; Lyman, 1865: 190; Norman, 1865: 105.

*Gorgonocephalus linckii*: Lyman, 1882: 264; Hoyle, 1885: 138; Bell, 1892: 137–138; Grieg, 1902: 18; 1904: 35; 1913: 130; Farran, 1913: 49; Koehler, 1924: 223.

MATERIAL STUDIED. COB: BIOGAS HZ Stn CV21 994 m 1 specimen.

SMBA: RRS *Challenger II* Stn 8 56°23'N: 9°18'W 1010–1030 m 1 specimen.

BMNH: Lousy Bank 60°20'W: 12°40'W 183–366 m Ministry of Agriculture & Fisheries 5 specimens; Christiansund 274 m 1 specimen; Rodberg, Trondheim Fjord 457 m 2 specimens.

The disk is pentagonal, up to 90 mm in diameter and covered with small stumpy spinelets which have a multipointed crown. In small specimens of disk diameter less than 20 mm the spinelets are not well developed and resemble low hemispherical granules. Occasionally some specimens do not have such a dense covering of spinelets and the interradial areas have only a few scattered spinelets with a greater number on the radial shields. The radial shields are long and bar-like reaching almost to the middle of the disk. The ventral interradial areas are similar to the dorsal surface.

The jaws are armed with spine-like mouth papillae, otherwise covered by thick skin which obscures the associated plates. This area and the ventral parts of the arms have a coating of granules. The genital slits are relatively long extending from the edge of the disk to half way towards the oral frame.

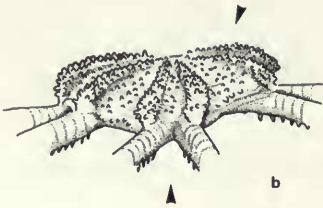
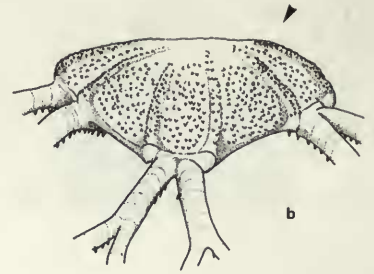
The arms are densely granulated. The first branch is close to the edge of the disk often within the disk edge. Hooks are found on segments after the second branching but they do not form complete rings until beyond the third or fourth branch; in juvenile specimens the rings may appear after the second branch. Hooks not arranged in a complete band, are often arranged in discreet units separated from one another. The first tentacle pore on the arm has no arm spines associated with it, the second has one spine the third has two and subsequent ones have three or four.

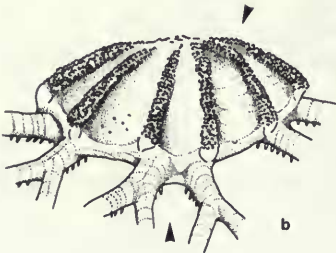
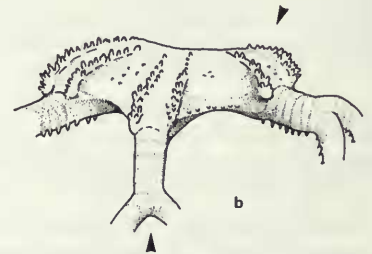
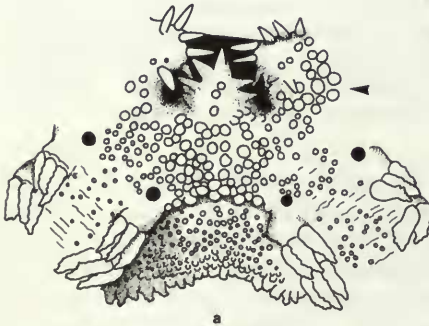
REMARKS. *G. caputmedusae* can be distinguished from the other Atlantic species of *Gorgonocephalus* by the spinelets and their arrangement. Even specimens which have a sparse covering of spinelets and therefore resemble *G. arcticus* can be distinguished by the multipointed crown of the spinelets and by the occurrence of spinelets in the interradial areas. Spinelets are confined to the radial shields in *G. arcticus* and more closely resemble large granules. *G. caputmedusae* differs from *G. lamarcki* by the density and type of disk covering. In *G. lamarcki* (Fig. 8) the disk is densely covered by small, skin-covered granules causing several authors to remark on its velvet-like appearance. In addition *G. lamarcki* does not have a dense covering of granules in the oral region and ventral part of the arms and it has a maximum of five arm spines not four as in *G. caputmedusae*. *G. eucnemus* (Fig. 8) differs from *G. caputmedusae* by the following characters: the disk is covered by hemispherical granules which occur more densely on the radial shields than interradially and in some large specimens the interradial areas look bare until examined closely.

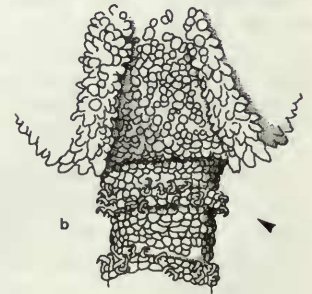


## GORGONOCEPHALIDAE

## Gorgonocephalus

*G. caputmedusae**G. lamarcki*

$$\frac{b}{1\text{cm}}$$
*G. eucnemus**G. arcticus**Astrochele lymani*

$$\underline{a, b, c}$$


**Fig. 8** Key to the Gorgonocephalidae. *Gorgonocephalus* and *Astrochele* (a) ventral; (b) dorsal view of disk; (c) lateral view of arm. NB. Bar scales associated with *Gorgonocephalus* = 1 cm; Bar scales associated with *Astrochele* = 1 mm.

The ventral part of the arms does not have the small granules found in *G. caputmedusae*. *G. caputmedusae* differs from *G. arcticus* (Fig. 8) as follows: the arms are densely covered in granules which are absent or sparse in *G. arcticus*; in *G. arcticus* the granules or low spinelets are confined to the radial shields with a very sparse scattering of smaller granules interradially.

**DISTRIBUTION.** *G. caputmedusae* is confined to the eastern Atlantic and has been recorded from Norway south to the Bay of Biscay with a bathymetric range of 150–1200 m.

*Astrochele lymani* Verrill, 1878

Fig. 8

*Astrochele lymani* Verrill, 1878: 374; 1885: 264, 407. Döderlein, 1927: 89.

**MATERIAL STUDIED.** **COB:** BIOGAS Stn 1: CV09 2119 m 2 specimens; CV39 2350 m 4 specimens; CPO8 2177 m 2 specimens; CP26 2115 m 3 specimens; BIOGAS Stn 2: CP09 2171 m 1 specimen.

**IOS:** *Discovery* Investigations: Stn 9042 45°15'N: 11°22'0"W 1662–1541 m 7 specimens.

The disk is subpentagonal often slightly domed, disk diameter up to 14 mm. The radial shields are prominent, rib-like and widely separated. They and the disk are covered by a dense coating of low rugose granules which are often slightly larger on the radial shields and the distal edge of the disk. The ventral inter-radial areas are also covered with low rugose granules.

There is usually one spine-like apical papilla flanked by several similar spiniform oral papillae. The oral area is covered with skin, often with small granules, which extends on to the ventral surface of the arms. The genital slits extend the full length of the ventral interradiial areas.

The arms are long, undivided, often coiled. The upper surface of the arms are covered with a dense coating of granules and segmental bands of hooks. Each band has two rows of hooks. The hooks are long and glassy with several supplementary points below the terminal hook. Between each band of hooks there are three bands of granules. There are usually three rugose arm spines from the first tentacle pore situated ventrally on the arm, their position corresponding with the bands of hooks. The cleaned arm spines are rugose with several long points.

**REMARKS.** *Astrochele lymani* can be readily identified by the bands of hooks on the undivided arms, the granular covering of the disk and the spine-like mouth papillae.

**DISTRIBUTION.** *A. lymani* has been recorded from both sides of the North Atlantic: in the western Atlantic it has been recorded off Nantucket in 547–1764 m while in the eastern Atlantic it has been found in the Bay of Biscay and off Portugal at depths of 1541–2350 m.

**ASTERONYCHIDAE** Verrill, 1899 emend Mortensen, 1933b

This family is characterised by a large well defined disk usually covered with thick skin or indistinct scales; the radial shields long and bar shaped; the papillae on the jaw may be spine-like or block-like; the genital slits on the proximal part of the ventral interradiial areas; the arms long and covered with skin.

There are two genera represented in the abyssal North Atlantic: *Asteronyx* Müller & Troschel, 1842 which has spine-like mouth papillae, skin covered disk and 8–9 arm spines; and *Astrodia* Verrill, 1884 which has block-like mouth papillae, scales on the disk and only 3 arm spines. Species of the two genera are frequently found clinging to pennatulids and gorgonians.

*Asteronyx loveni* Müller & Troschel, 1842

Fig. 9

*Asteronyx loveni* Müller & Troschel, 1842: 199; M. Sars, 1861: 5; Norman, 1865: 98–129; Lyman, 1882: 285; 1883: 282; Verrill, 1885: 550; Grieg, 1893: 29; Koehler, 1897: 370; 1904: 167; Sussbach & Breckner, 1911: 262; H. L. Clark, 1911: 285; Döderlein, 1911: 115; Mortensen, 1912: 264–287; Matsumoto, 1917: 33; Koehler, 1922: 34; H. L. Clark, 1923: 314; Koehler, 1924: 227; May, 1924: 269; Rivera Galle, 1926: 17; Döderlein, 1927: 59; Mortensen, 1927: 158; Fedotov, 1929: 170; Koehler, 1931: 23; Baranova, 1957: 186; Chang, Liao & Wa, 1965: 61–62; Rowe, 1971: 574; Cherbonnier & Sibuet, 1972: 1364; Gage *et al.*, 1983: 287.

ASTERONYCHIDAE

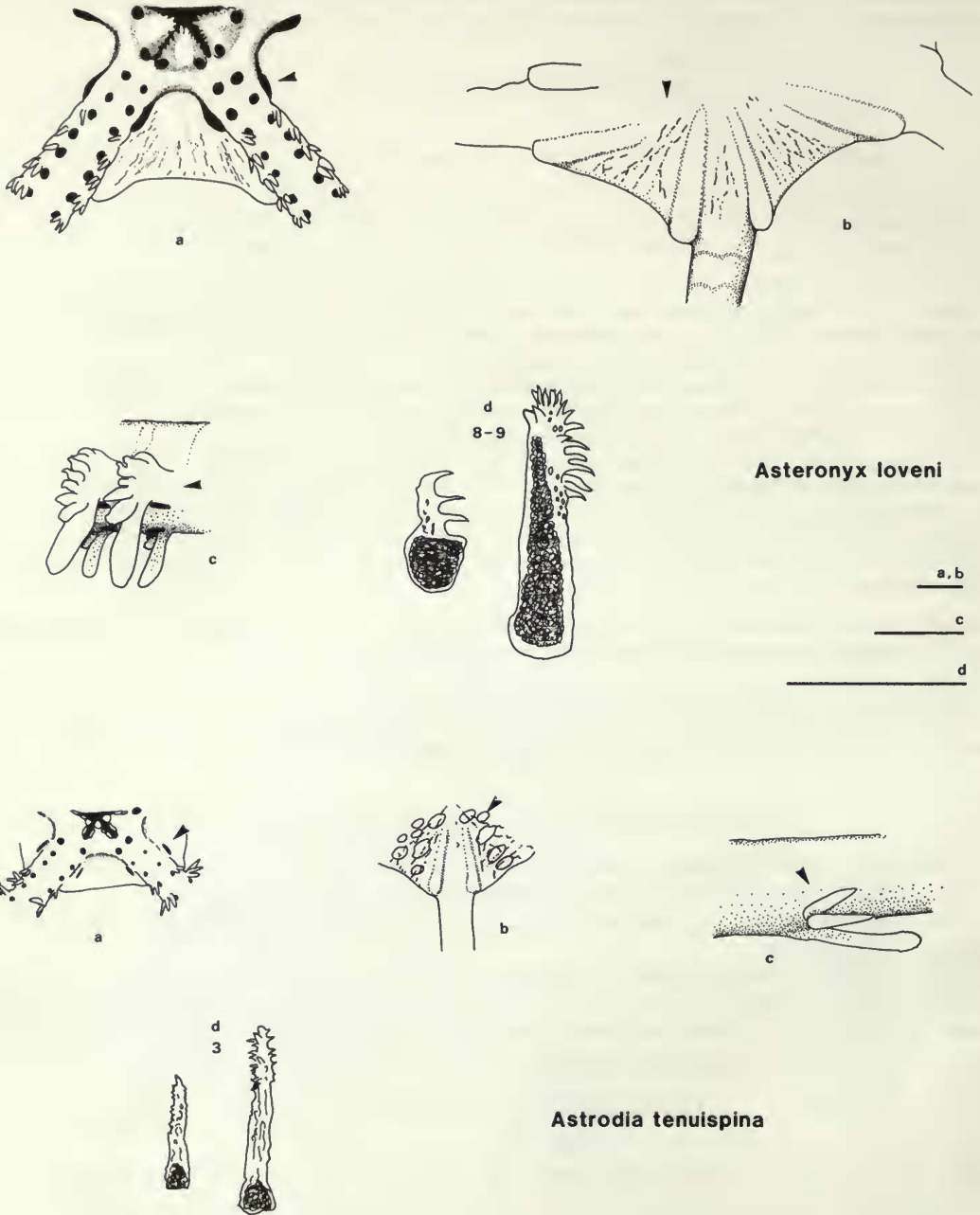


Fig. 9 Key to the Asteronychidae. *Asteronyx* and *Astrodia* (a) ventral; (b) dorsal view of disk; (c) lateral view of arm; (d) arm spines number with the spine indicates the number of arm spines on the middle segments of the arm. Bar scales = 1 mm.



*Asteronyx locardi* Koehler, 1896a: 88; 1907: 303; Grieg, 1921: 38.

*Asteronyx dispar* Lütken & Mortensen, 1899: 185; H. L. Clark, 1913: 219.

*Asteronyx cooperi* Bell, 1909: 22.

MATERIAL STUDIED. **BMNH:** HMS *Challenger* Stn 49 off Nova Scotia 152 m 1 specimen; *Porcupine* off the Minch, Norman Collection 3 specimens.

**COB:** BIOGAS Stn 1: CV24 2025 m 5 specimens; CP01 2245 m 8 specimens; CP02 2174 m 4 specimens; CP03 2119 m 2 specimens; CV39 2350 m 1 specimen; CP08 2177 m 1 specimen. BIOGAS Stn 2: CV26 2822 m 1 specimen; BIOGAS Stn 4: CV35 4721 m 1 specimen; BIOGAS HZ Stn: CV11 2141 m 1 specimen.

**SMBA:** RRS *Challenger II*: Stn SWT 18 56°46'N: 09°42'W 1809 m 1 specimen; Stn SWT 32 56°48'N: 09°56'W 2006 m 1 specimen.

The disk is round to pentagonal, and covered in skin with occasional small plates, usually only noticeable when the specimen is dried; disk diameter up to 35 mm. The radial shields are long, bar shaped reaching almost to the centre of the disk. The ventral interradial areas are also covered with skin.

The jaws and oral area are covered by skin. The jaws appear as if recessed within the mouth. The jaws are armed with blunt papillae which are not arranged in a regular series. The second oral tentacle pore emerges superficially. The genital slits are small about one segment long and are situated beside the arm between the first and second tentacle pores.

The arms are covered with skin, and are very long with two or three longer than the others. Dorsal arm plates are absent and the ventral arm plates are obscured by skin. The arm spines are situated on the ventral side of the arms usually just proximal to the tentacle pore. There are no spines on the first arm segment, one on the second, two on the third increasing up to 8 or 9. These spines are slightly rugose and hook shaped. On the longer arms the ventralmost arm spine is elongated, about four times as long as the other spines, and is club shaped. The arm spines are usually covered with skin. When cleaned the shorter ones are revealed to be rather hook-like with a terminal hook and 2 large supplementary hooks on the shaft. The longer spines are mace-like; with a slightly rugose body and a head with multiple points.

**REMARKS.** *Asteronyx loveni* can be distinguished by the skin covered disk; the bar shaped radial shields which reach almost to the centre of the disk; the blunt mouth papillae; the 8 to 9 arm spines on the arm and the well developed club shaped arm spine on the longer arms.

**DISTRIBUTION.** *Asteronyx loveni* appears to be widespread in distribution, there being no records from the Arctic Ocean and parts of the Southern Ocean; the bathymetric range is wide; from c. 100–4721 m.

### *Astrodia tenuispina* Verrill, 1884

Fig. 9

*Astrodia tenuispina* Verrill, 1884: 219; 1899b: 371; Koehler, 1906: 33–34; 1907: 304–5; Gage *et al.*, 1983: 287–288.

*Hemieuryale tenuispina*: Verrill, 1885: 550.

MATERIAL STUDIED. **COB:** BIOGAS Stn 1: CV10 2108 m 1 specimen; BIOGAS Stn 2: DS19 2865 m 1 specimen; DS 41 3548 m 2 specimens; DS66 3480 m 3 specimens; CV26 2822 m 1 specimen; CP28 3380 m 2 specimens. BIOGAS HZ Stn: DS 14 1560 m 1 specimen.

**IOS:** *Discovery* Investigations: Stn: 8511/2 41°49'6"N: 11°6'0"W 2274–2584 m 4 specimens; Stn 9640/1 50°3'2"W: 13°50'6"W 8 specimens.

**SMBA:** RRS *Challenger II*: Stn SWT 13 52°04'N: 16°09'W 3463 m 147 specimens.

The disk is pentagonal, disk diameter up to 10 mm; the skin covering has numerous rounded thin scales embedded in it, usually most conspicuous when the specimen is slightly dried. The radial shields are bar-like almost reaching the middle of the disk. Distally the pair of shields terminates on each side of the arm. The ventral interradial areas are similar to the dorsal surface.

The jaw bears one pointed apical papilla flanked by up to 5 block-like, contiguous oral papillae. The second oral tentacle pore arises superficial. The other plates of the jaw are often conspicuous. The adoral shields are large and broad. The oral shield is usually small, rounded, triangular except the madreporite which is usually large. The genital slits are short equal to about one arm segment, and are situated by the side of the arm between the first and second tentacle pore on the ventral interradial area.

The arms are long, with no dorsal arm plates and the ventral arm plates hidden by skin. The arm spines are situated on the ventral side of the arms proximal to the tentacle pore. There are no spines on the first arm

segment, one on the second, two on the third then three on the remaining arm segments. The arm spines are thin and pointed with the ventralmost becoming elongated up to three times the length of the others and developing a rugose multipointed crown. When the arm spines are cleaned in bleach the smaller ones are seen to be thin and only slightly rugose with the area of attachment reinforced while the larger spine has an almost smooth shaft with a multipointed head.

**REMARKS.** *Astrodia tenuispina* can be recognised by the skin covered disk embedded with small thin plates; jaws with a pointed apical papilla and as many as 5 contiguous block like oral papillae, and 3 arm spines of which the ventral most is the longest.

**DISTRIBUTION.** *A. tenuispina* has been recorded from both sides of the North Atlantic. In the west from off the east coast of the United States at depths of 2452–3659 m; in the east from the Rockall Trough, the Porcupine Sea Bight, the Bay of Biscay and off Portugal with a bathymetric range of 1560–3548 m.

### ASTEROSCHEMATIDAE Verrill, 1899 emended Mortensen, 1933b

This family is characterised by the disk being ill-defined or constricted with the arms appearing to continue to the centre of the disk in some genera; the disk may be covered with skin or a dense coating of granules; the long and narrow radial shields; the reduced papillae on the jaw with only the apical papillae well developed and the oral papillae small, like enlarged granules; the genital slits situated vertically on the sides of the disk; the arms long and covered with skin or granules. There are two genera present in the North Atlantic abyssal: *Asteroschema* Orsted & Lütken, 1856, which is densely covered with granules and has a small ill-defined disk, and *Ophiocreas* Lyman, 1879, which is covered mainly by skin although the disk has a light covering of small granules and the disk is slightly larger and more distinct. Species of both genera are frequently found on gorgonians and corals.

#### *Asteroschema inornatum* Koehler, 1906

Fig. 10

*Asteroschema inornatum* Koehler, 1906: 30–31; 1907: 303–304; 1909: 206; A. H. Clark, 1948: 78; Gage *et al.*, 1983: 288.

**MATERIAL STUDIED.** **COB:** BIOGAS Stn 6 CV32 1895 m 1 specimen; CP07 2170 m 16 specimens.

**IOS:** *Discovery* Investigation Stn 9042 42°15'N: 11°12'W 1662–1541 m 2 specimens.

**SMB:** RRS *Challenger II*: Stn ES 112 55°12'N: 15°50'W 1900 m 1 specimen.

The disk is small and ill-defined with the arms appearing to continue to the middle of the disk. The disk diameter may reach 10 mm. Both disk and arms are densely covered with granules. The radial shields are covered but can be distinguished as two long swellings at the base of the arms, reaching to the centre of the disk.

The ventral side is also densely covered with granules obscuring the underlying plates. The jaws bear one large blunt apical papilla. The oral papillae are reduced and resemble large flattened granules. The second oral tentacle pore arises superficially. The genital slits are short and situated on the vertical sides of the interradial areas of the disk.

The arms are very long, greater than seven times the disk diameter. The plates of the arms are obscured by granules. The first tentacle pore lacks an accompanying spine, the second to fourth have only one spine subsequent pores have two. The inner one of the pair becomes larger and club-like on distal arm segments.

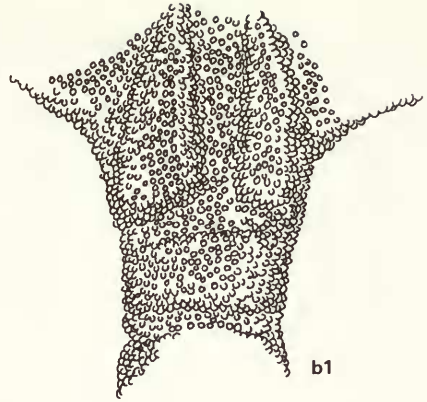
**REMARKS.** *A. inornatum* can be distinguished by the small ill-defined disk, the dense covering of granules, the genital slits positioned vertically on the sides of the disk, the arrangement of the jaw and the arrangement of the arm spines.

**DISTRIBUTION.** *A. inornatum* has been recorded from the Rockall Trough, the Bay of Biscay, off NW. Spain and off the Azores; with a bathymetric range of 1478–2170 m.

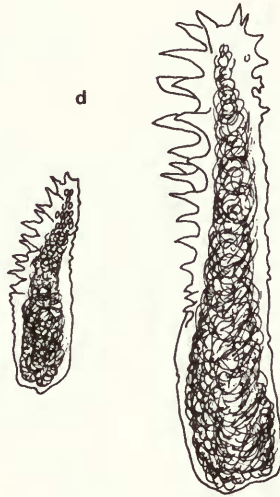
## ASTEROSCHEMATIDAE



a1



b1

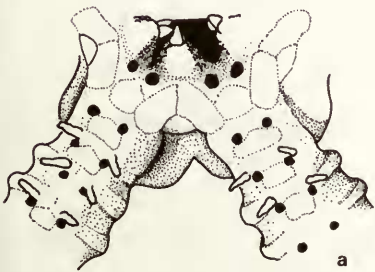
**Asteroschema inornatum**

d

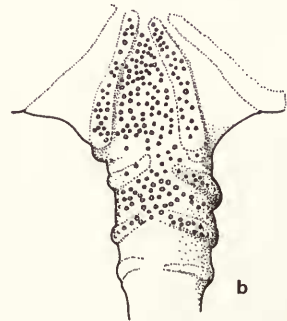
a,b

a1,b1

d



a



b

**Ophiocreas oedipus**

Fig. 10 Key to the Asterocheimatidae. *Asteroschema* and *Ophiocreas* (a) ventral; (b) dorsal view of disk; (d) arm spines. Bar scales = 1 mm.



*Ophiocreas oedipus* Lyman, 1878

Fig. 10

*Ophiocreas oedipus* Lyman, 1878: 65; 1882: 283; Koehler, 1904: 166; 1909: 206.

**MATERIAL STUDIED.** BMNH: HMS *Challenger* Stn 344 off Ascension Island 756 m HOLOTYPE; HMS *Challenger* Stn 343 off Ascension Island 778 m 2 PARATYPES.

**DIAGNOSIS.** The disk is small indented interradially; the disk diameter up to 12 mm. The arms do not appear to extend to the middle of the disk as in *Asteroschema inornatum*. Both the arms and disk appear covered with skin, but close examination of the disk reveals small granules, which covers the disk but less densely than in *Asteroschema*. Although covered the radial shields are conspicuous, bar shaped nearly extending to the middle of the disk.

The ventral side of this species is covered by skin but without any granules. The jaws bear one broad pointed apical papilla. The oral papillae are reduced resembling irregularly arranged, enlarged granules. The second oral tentacle pore arises superficially above the jaws, when viewed ventrally. The genital slits are almost vertical placed on the interradiial areas of the disk.

The arms are long and thin, greater than seven times the disk diameter. In larger specimens the base of the arms may be enlarged, three or more arm segments may be effected, this is an indication of the degree of gonad development. The first tentacle pore on the arm has no spine associated, the next five or so pores have one and subsequent ones have two. The inner spine becomes enlarged and clublike on distal segments.

**REMARKS.** *O. oedipus* can be distinguished from *Asteroschema inornatum* by the following characters: the disk is not densely covered by granules, the disk is more developed and the ventral areas are skin covered.

**DISTRIBUTION.** *O. oedipus* appears to be widely distributed having been recorded from both Atlantic and Pacific Oceans. In the North Atlantic it has been recorded from off Madeira with a bathymetric range of 1500–1970.

## OPHIURAE Müller &amp; Troschel, 1842

## OPHIOMYXIDAE Ljungman, 1867b

This family is characterised externally by thickened skin covering the disk and arms which conceals the reduced or fragmented plates or scales; rudimentary and inconspicuous radial shields; the jaws usually as broad as long or longer than broad armed with simple spine-like or broad scale-like rugose papillae; the second oral tentacle pore may arise within the mouth slit as in *Ophiomyxa*, or more superficially and nearly outside the mouth slit as in *Ophioscolex* and *Ophiophrixus*; oral area usually covered with skin which may obscure the underlying plates; the arm spines erect laterally placed, covered with thickened skin.

*Ophiomyxa serpentaria* Lyman, 1883

Fig. 11

*Ophiomyxa serpentaria* Lyman, 1883: 274; Bell, 1892: 136; Farran, 1913: 47–48; Mortensen, 1913b: 362; 1927: 168; 1933a: 11–14; Cumano, 1941: 1–7.

*Ophioderma serpentaria* Verrill, 1899a: 67; Koehler, 1909: 203.

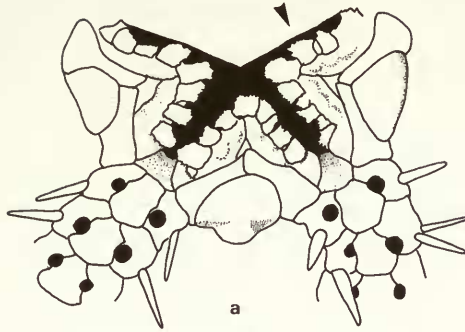
**MATERIAL STUDIED.** BMNH: *Helga* Stn CXX 53°58'N: 12°24'W 688 m 1 specimen.

**IOS:** *Discovery* Investigations: Stn 8966 31°21'N: 6°41.5'W–31°22'N: 10°39.2'W 686–742 m 1 specimen.

The disk is pentagonal; covered with skin in which it is possible to discern small thin transparent plates; disk diameter up to 27 mm. The radial shields are inconspicuous. Along the margin of the disk there is a series of fairly distinct plates. The ventral interradiial areas are covered with skin, like the dorsal surface. Mortensen (1933a) mentions that the skin of the disk also contains small irregular, bone shaped spicules.

The jaw is as broad as long. There is one apical papillae flanked on each side by 3–4 oral papillae. The papillae are broad and glassy with rugose tips; webs of skin connect their bases. The adoral shields are long and slightly flared distally, separating the oral shield from the first lateral arm plate. The oral shield is large, rounded triangular in shape often with a slight distal projection.

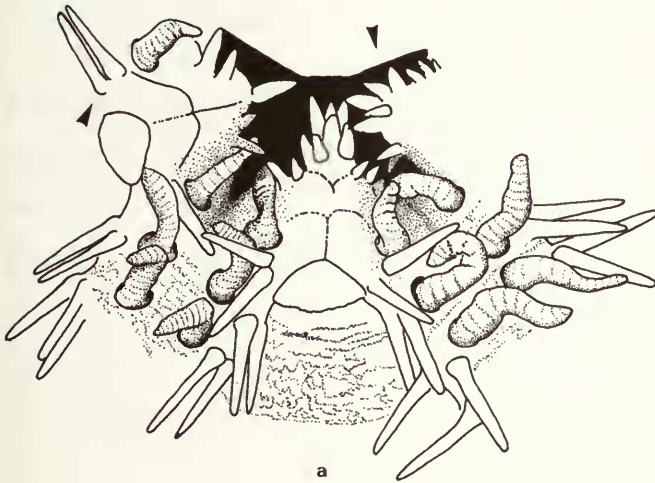




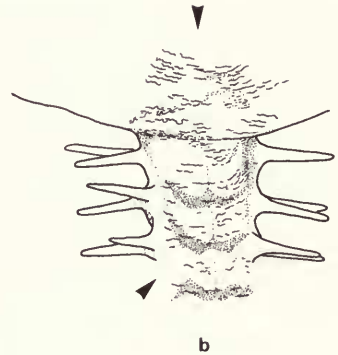
**Ophiomyxa serpentaria**

a, b, c

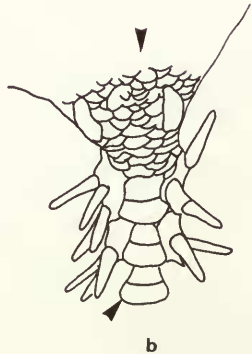
d



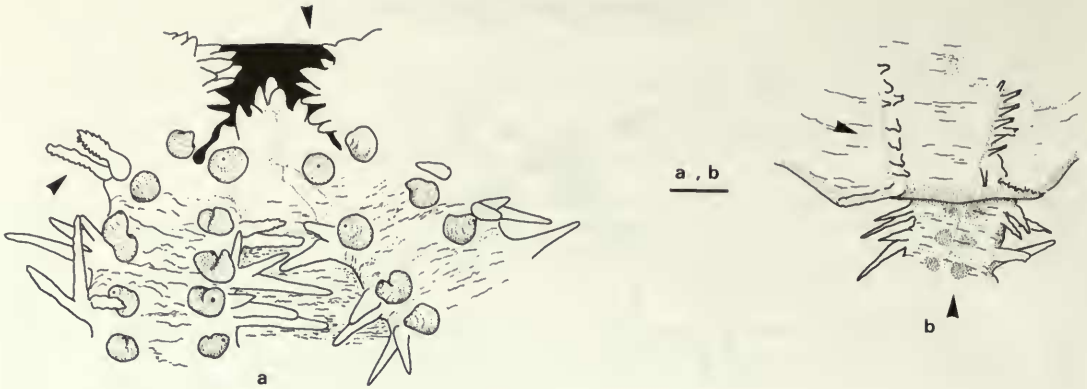
**Ophioscolex glacialis**



**Ophioscolex purpureus**



**Fig. 11** Key to the Ophiomyxidae *Ophiomyxa* and *Ophioscolex* (a) ventral; (b) dorsal view of disk; (d) distal dorsal arm spine. Bar scales = 1 mm.



### Ophiophrixus spinosus

Fig. 12 Ophiomyxidae *Ophiophrixus* (a) ventral; (b) dorsal view of disk. Bar scales = 1 mm.

The arms are covered by skin. The dorsal arm plates are very thin, visible only in dried specimens and often it is necessary to dissolve away the skin, nearly rectangular and contiguous or nearly so at least on proximal segments. The ventral arm plates are irregularly hexagonal, with the lateral edges extending laterally; broadly contiguous on proximal joints. The tentacle pores are large and open without tentacle scales, gradually becoming smaller on the distal segments. There are three skin covered arm spines, proximal spines are rugose but towards the end of the arm, all the spines become more hook-like.

REMARKS. *O. serpentaria* can be distinguished by the shape of the apical and oral papillae, the skin covered disk and the marginal series of plates on the disk.

DISTRIBUTION. This species has only been recorded from the eastern Atlantic from SW. Ireland, Faeroe Channel south to the Azores; with a bathymetric range of 450–2440 m.

### *Ophioscolex glacialis* Müller & Troschel, 1842

Fig. 11

*Ophioscolex glacialis* Müller & Troschel, 1842: 109; Lyman, 1883: 268; Verrill, 1885: 549; Bell, 1892: 134; Grieg, 1893: 9; Pfeffer, 1894: 107–121; Grieg, 1900: 268; 1902: 16; 1903: 32; Michailovskij, 1902: 533; Mortensen, 1903: 86; Grieg, 1910: 6; Süßbach & Breckner, 1910: 259; Mortensen, 1913: 361; Koehler, 1914: 124; Hofsten, 1915: 117; Mortensen, 1927: 169; Schorygin, 1928: 60; Mortensen, 1932: 25; 1933a: 14; Hedling, 1934: 57; Djakanov, 1935: 82; 1954: 30; Stendall, 1967: 837.

MATERIAL STUDIED. BMNH. *Ernest Holt* Stn 24 off Greenland 3 specimens; Norman Coll. off Matha's Vineyard NE. America 360–464 m 3 specimens; west coast of Sweden 1 specimen.

IOS: *Discovery* Investigation Stn 7711 52°50'N: 20°02.8'W 2727 m 1 specimen.

The disk is round to pentagonal, delicate and frequently damaged so as to obscure the shape; covered with skin without any plates; disk diameter up to 25 mm. The radial shields are inconspicuous. The ventral intraradial areas are also covered by naked skin.

The jaws appear longer than broad. In large specimens there are several rounded blunt or often spine-like superficial apical papillae barely distinguishable from the ventralmost teeth; in smaller specimens there are fewer papillae, often only one. There are 3–4 large irregularly arranged oral papillae; distal to these and situated within the mouth slit is a series of 3 or 4 smaller papillae. The second oral tentacle pore emerges superficially and is armed with one or two large tentacle scales, situated on the adoral shields and similar to the arm spines. The adoral shields are long and slightly curved, indented over the area of the second oral tentacle pore. The oral shield has a rounded proximal edge with an almost straight distal edge or may be rounded triangular in shape.

The arms are covered with skin which obscures the dorsal side of the arm. Dried specimens reveal a lack

of dorsal arm plates. The ventral arm plates are irregularly rectangular with indented lateral edges and a rounded distal edge; they are contiguous at least proximally. The tentacle pores are large and open without tentacle scales; the tentacles themselves are long and not retractable and may obscure the plates beneath. There are 3 erect, slightly flattened, blunt arm spines, covered by thick skin.

REMARKS. *O. glacialis* can be distinguished from *O. purpureus* by the absence of tentacle scales; the shape and position of the second oral tentacle scales and by a lack of dorsal arm plates.

DISTRIBUTION. This species has been recorded on both sides of the North Atlantic and from Arctic Seas; in the east it has been recorded from the Kara Sea south to the Faeroe Channel and in the west from the Davis Strait south to off Maryland, with a bathymetric range of 50–2727 m.

*Ophioscolex (Ophiolycus) purpureus* Düben & Koren, 1844

Fig. 11

*Ophioscolex purpureus* Düben & Koren, 1844: 235; G. O. Sars, 1861: 8; Bell, 1892: 134; Grieg, 1893: 28; 1895: 10; 1902: 16; 1903: 32; Mortensen, 1903: 87; Koehler, 1907: 302; Farran, 1913: 47; Mortensen, 1913: 362; 1920: 45–48; 1927: 170; 1933a: 17; 1933b: 315; Djakanov, 1954: 30.

*Ophioscolex quadrispinus* Verrill, 1885: 550.

MATERIAL STUDIED. BMNH: *Porcupine* Stn 82 60°0'N: 5°13'W 562 m 15 specimens; *Porcupine* Stn 87 59°35'N: 9°11'W 1403 m 3 specimens; *Ernest Holt*, S. of Bear I. 4 specimens.

The disk is round to subpentagonal; covered with thickened skin; no scales but granules are scattered over the surface which are more conspicuous in dried specimens; disk diameter up to 20 mm. The radial shields are inconspicuous. The ventral interradial areas are similar to the dorsal surface.

The jaws appear to be longer than broad. The plates of the oral frame are often obscured by thickened skin. There are up to 3 flat pointed apical papillae flanked on each side by 4–5 flattened, pointed oral papillae. Distal to the oral papillae there are 2–3 large flat tentacle scales of the second oral tentacle pore, often forming a series with the oral papillae. The adoral shields are long and narrow, flared distally so that they separate the oral shield from the first lateral arm plate. The oral shield is rounded triangular.

The arms may be covered by a thin covering of skin which may obscure the plates. Distally the dorsal arm plates are well developed, rectangular and contiguous with two successive plates to each segment; at the base of the arms there is an irregular arrangement of many small plates merging into the disk, usually only distinctly seen in dried specimens. The ventral arm plates are rectangular contiguous with their lateral edges indented. The tentacle pores are large and open with one long flat tentacle scale. There are three flat, blunt, finely rugose arm spines, on the distal portion of the arm the two dorsalmost ones are transformed into hooks.

REMARKS. *O. purpureus* can be distinguished by the presence of dorsal arm plates, the arrangement of the tentacle scales of the second oral tentacle pore, the presence of one long flat tentacle scale on each arm pore and the transformation of the dorsal spines into hooks.

Mortensen (1933b) erected a sub-genus for those species of *Ophioscolex* with well formed dorsal arm plates and well developed hooks on the arms. In addition their jaws are better developed and similar in structure to those of the ophiacanthid subfamily Ophiotominae. However *Ophioscolex* can be distinguished from the Ophiotominae because it lacks the comma shaped arm spine articulation on the lateral arm plate, and by having the distal dorsal spines transformed into hooks.

DISTRIBUTION. *O. purpureus* has been recorded from Greenland, Norway, the Rockall Trough south to the Bay of Biscay, with a bathymetric range of 75–1480 m.

*Ophiophrixus spinosus* (Storm, 1881)

Fig. 12

*Ophioscolex ? spinosa* Storm, 1881: 88.

*Ophiobyrsa hystericis* Lyman, 1883: 272; Bell, 1892: 135; Kemp, 1905: 196; Koehler, 1907: 302; Farran, 1913: 48; H. L. Clark, 1915: 170.

*Ophiobyrrella hystericis*: Verrill, 1899b: 359.

*Ophiophrixus spinosus*: Mortensen, 1924: 3–11; 1927: 171; 1933a: 18–20.



MATERIAL STUDIED. BMNH: HMS *Research* Stn 2 1 specimen; Ministry of Agriculture and Fisheries 60°20'N: 12°40'W 180–360 m; The Lousey Bank 1 specimen; Irish Fisheries *Helga* Stn SR 188 51°53'N: 11°59'W 576–670 m 2 specimens.

The disk is round, often indented interradially, high and covered with skin with small scattered spines attached to small plates within the skin; diameter up to 30 mm. The radial shields are short and bar-like and carry a single row or well developed spinelets along their length. The ventral interradiial areas are similar to the dorsal side of the disk.

The jaws and other plates of the oral surface are obscured by skin. The jaws are as long as broad. There may be up to 3 apical papillae although it is difficult to differentiate these papillae from the teeth. There are 3 oral papillae situated within the mouth slit below the level of the second oral tentacle pore which emerges quite superficially. There are no tentacle scales associated with the second oral tentacle pore. The adoral shields are wing-like often completely separating the oral shield from the first lateral arm plate. The oral shield is rounded, rhombic in shape.

The arms are long up to 10 times the disk diameter, covered with skin which obscures the underlying plates. The dorsal arm plates of each segment consist of two separate oval plates lying side by side isolated from the preceding and succeeding ones. The ventral arm plates are rounded pentagonal with a rounded obtuse proximal angle and with the distal edge indented and are contiguous proximally. The tentacle pores are large and open without any tentacle scales. There are 5 arm spines obscured by thick skin; when denuded they appear glossy and quite rugose with large secondary points along the shaft of the spine.

REMARKS. *O. spinosus* can be distinguished by the thin bar shaped radial shields which carry a single row of spinelets, the pointed oral and apical papillae, the lack of tentacle scales on the second oral tentacle pore and the thick skin which covers the disk and arms.

DISTRIBUTION. *O. spinosus* has been recorded from the Denmark Strait, off SE. Iceland and south to the Azores, with a bathymetric range of 40–1310 m.

### OPHIACANTHIDAE Perrier, 1891

A family with the disk ranging from a sack-like bag covered with skin or thin scales to a more rigid structure covered with large plates, usually armed with spinelets, granules, or simple rods, the density of covering varying; the characters of the oral frame falling into broad categories: either the jaws longer than broad with many papillae or as broad as long usually with fewer papillae, rarely more than 6–7; the arms usually noded but sometimes only slightly so; arm spines usually erect, often long and rugose; the tentacle pores either large and open with small tentacle scales or none at all or small with a variety of tentacle scales.

REMARKS. The diagnosis above is a very general definition of this family which is a taxonomist's nightmare defying a unified description because of the variety of generic forms. The problem is that while the species of ophiacanthids are generally well described, most of the genera and families are ill-defined. Several authors (Verrill, 1899*a, b* and Matsumoto 1915, 1917) have attempted to revise the family but none of the schemes have been accepted in their entirety. At the risk of adding to the confusion four sub-divisions of the Ophiacanthidae are proposed for testing. The characters upon which these subdivisions are based are as follows: the nature of the arm spine articulation surface of the lateral arm plate, the SEM has revealed that the majority of genera studied in this family have one form, a comma-shaped tubercle (Fig. 13) but one genus, *Ophiomyces*, does not. Such is the widespread occurrence of this character that its absence prompts separating *Ophiomyces* and possibly *Ophiotholia* and *Ophiohelus* into a subfamily. The second set of characters used are the nature of the covering of the disk, and the form of the radial shields. These characters fall into two broad categories, the radial shields are sometimes bar-like and long, often covered over by the disk covering which is usually small thin scales or occasionally stouter scales, or a disk covered by distinct plates with the radial shield distinct



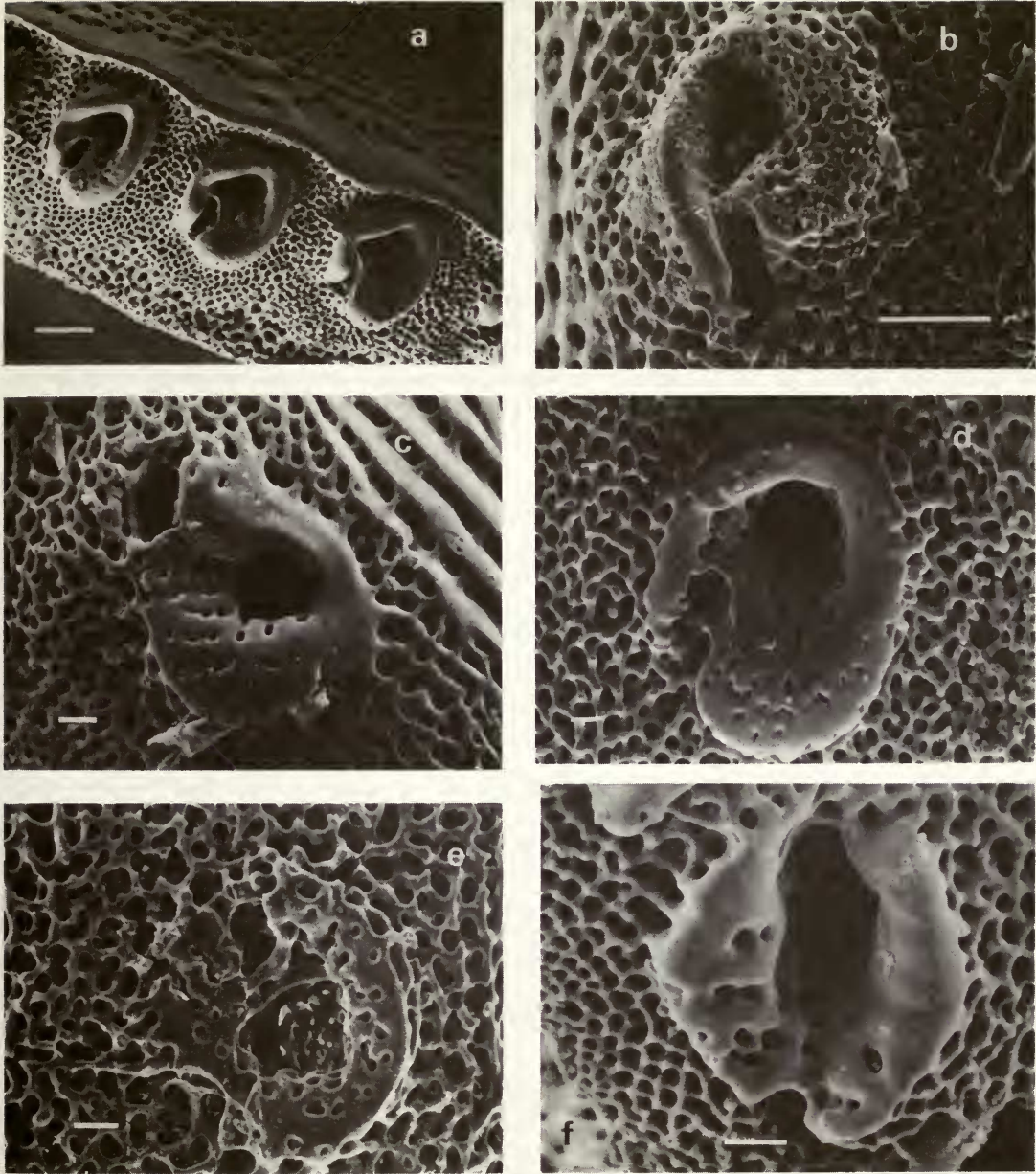


Fig. 13 Ophiacanthidae. SEM photographs of the arm spine tubercles on the lateral arm plate of: (a) *Ophiacantha aristata*, (b) *Ophiotoma coriacea*, (c) *Ophiocymbium cavernosum*, (d) *Ophioplinthaca abyssalis*, (e) *Ophiocamax dominans*, (f) *Ophiomyces fructosus*. Bar scales a, b = 100  $\mu$ , c-f = 30  $\mu$ .

and integrated with the other plates. The final series characters used are the appearances of the jaw and the arrangement of the mouth papillae and tentacle pores. Again there are two broad categories: either the jaws appear longer than wide with many oral papillae and large open tentacle pores or the jaw appears as broad as long with few oral papillae and small tentacle pores.

The four subfamilies; Ophiacanthinae, Ophiotominae, Ophioplinthacinae and Ophiohelinae, are treated in detail under their respective headings.

### Characters of taxonomic importance in the Ophiacanthidae

1. **The disk** (*a*) whether it is covered by small scales or by distinct plates; (*b*) most scales or plates carry one or more spinelets, the shape and density of these spinelets are important; (*c*) in some species of the subfamily Ophioplithacinae the shape and position of radial shields is important. In the other subfamilies the radial shields are partially or totally hidden.
2. **The jaw:** the characters are: (*a*) the shape of the jaw; (*b*) the shape and arrangement of the apical and oral papillae; (*c*) the shape of the adoral and oral shields; (*d*) in species of the Ophiotominae the arrangement of the tentacle scales associated with the second oral tentacle pore and their alignment with the oral papillae.
3. **The arms:** (*a*) the form of the tentacle pore; (*b*) the number and shape of the arm spines, the degree of rugosity; (*c*) the number and shape of the tentacle scales; (*d*) whether the arm spines of the proximal joints meet midradially forming a fan when viewed transversely; (*e*) often in outline the arms may appear to be constricted between the rows of arm spines usually because the articulation areas are elevated. The taxonomic significance of this noded shape has yet to be fully investigated.

### OPHIACANTHINAE Sub Family nov

**DIAGNOSIS.** A subfamily of the Ophiacanthidae with small imbricating transparent scales or skin covering the disk, the scales often armed with spinelets or granules which may obscure them; the disk sack-like, sometimes indented interradially; the radial shields not integrated with the disk but overlaid by the scales or skin covering the disk with only their distal ends evident; the jaws as broad as long; one to several apical papillae flanked by three to many oral papillae each side; tentacle pores not conspicuously large usually armed with at least one tentacle scale; arm spines vary in length but dorsal ones usually longer than one arm segment, sometimes forming a fan on proximal arm segments.

**TYPE GENUS.** *Ophiacantha* with type species *O. bidentata* (Retzius)

**REMARKS.** The genera now included in this subfamily are: *Ophiacantha* Müller & Troschel, 1842; *Ophiacanthella* Verrill, 1899; *Ophialcaea* Verrill, 1899; *Ophiogema* Koehler, 1922a; *Ophiolebes* Lyman, 1878 and *Ophiotreta* Verrill, 1899. The genera *Ophialcaea* and *Ophiotreta* were treated as subgenera of *Ophiacantha* by Mortensen (1936) and Fell (1960), but H. L. Clark (1915) and Koehler (1922, 1931) considered them to be of generic rank, a treatment followed here pending future study on the generic boundaries in this subfamily.

The most important characters which distinguish the Ophiacanthinae are the often long and narrow mainly internal radial shields; the small scale-like plates of the disk and the relative broad jaw coupled with a relatively simple arrangement of apical and oral papillae.

### *Ophiacantha anomala* G.O. Sars., 1871

Fig. 14

*Ophiacantha anomala* G. O. Sars, 1871: 12; Verrill, 1885: 547; 1899a: 36; 1899: 324, 335; Grieg, 1902: 16; Mortensen, 1903: 86; 1913: 360; Koehler, 1914: 77; Mortensen, 1924: 115; 1927: 191; 1933a: 24–26.

**MATERIAL STUDIED.** **BMNH:** Trondheim Fjord Norway 450–540 m 1 specimen; *Porcupine* Stn 64 653 m 1 specimen.

This species usually has six arms. The disk is round, covered by tall rugose spinelets with multipointed crowns; disk diameter up to 11 mm. Only the tips of the radial shields are visible but the extent of the plate beneath the disk can be distinguished. The ventral interradiial areas are also covered with spinelets.

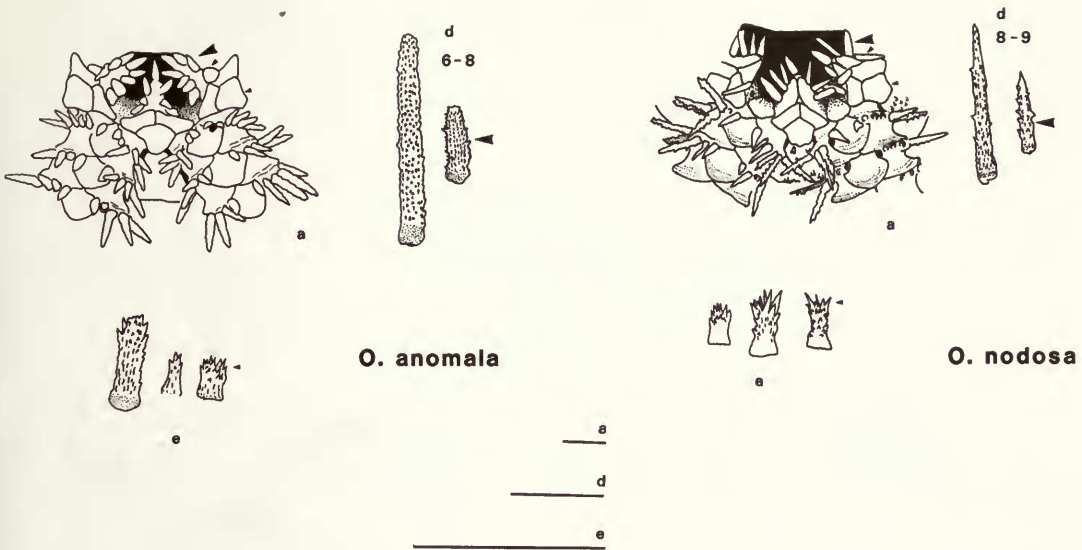
The jaws appear to be long and narrow. There is one thin spine-like apical papilla flanked by 3–5 oral papillae, occasionally there are many supernumerary papillae on the side of the jaw and over the adoral shields and jaw plates. The oral papillae are often long and the distalmost ones may be flared at the tips. The adoral shields are flared and wing-like separating or nearly separating the oral shield from the first lateral arm plate. The oral shield is a rounded pentagon with a straight distal edge and a rounded proximal one; in some specimens it may be more rounded, nearly oval.



**OPHIACANTHINAE**

**Ophiacantha**

**6 - ARMED SPECIES**

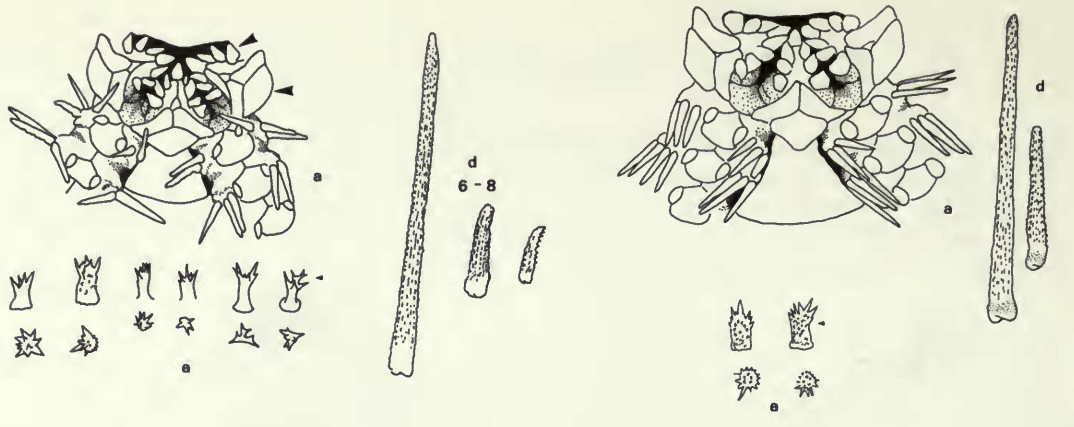


**Fig. 14** Key to the Ophiacanthidae: Ophiacanthinae, *Ophiacantha* = six armed species: (a) ventral view of disk; (d) arm spines—a number with this figure indicates the number of proximal arm spines. The larger spine is the dorsalmost, the smaller a ventral spine; in figures with only one arm spine it is the dorsalmost one. A number with an arrow pointing to an arm spine signifies the number of proximal arm spines. (e) Disk spinelets. NB. The ventral interradial areas have been left blank in certain figures for clarity. Bar scales = 1 mm, letters above the bars refer to the figures.

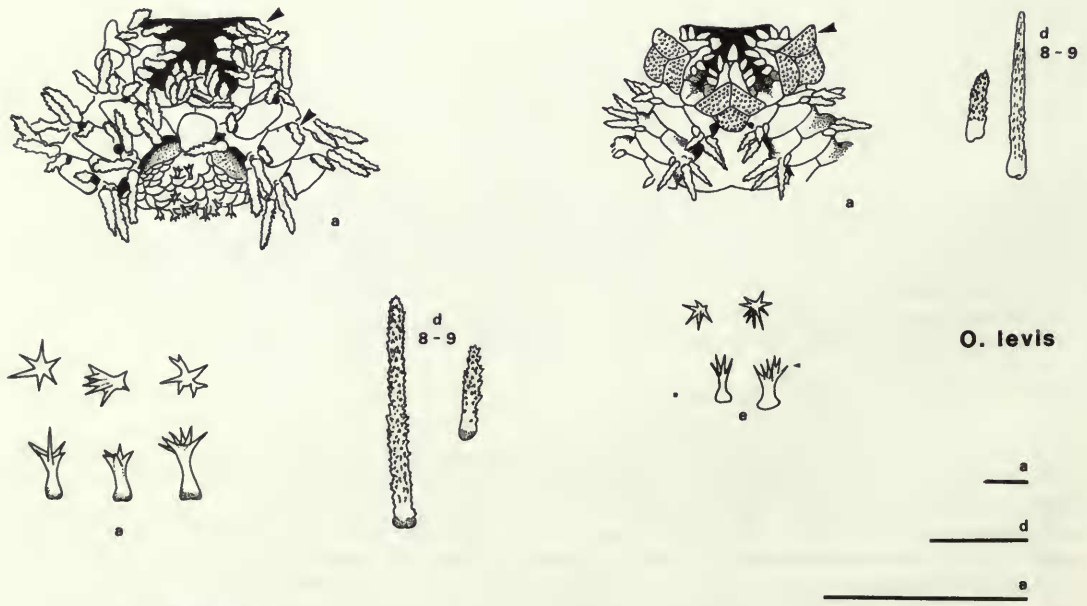
There are six slightly noded arms. The dorsal arm plates are rhombic to fan shaped and separated. The ventral arm plates are pentagonal with a rounded distal edge, which may also be slightly elevated, and are nearly contiguous. On the first tentacle pore on the arm there may be two large flat leaf shaped tentacle scales. Subsequent pores have only one. There are 6-8 arm spines proximally in large specimens, 4-5 in smaller ones. The ventralmost spines are finely rugose, the dorsal ones highly rugose. The dorsal or second dorsalmost spine is the longest. The arm spines do not form a fan across the first free joint.

**REMARKS.** *O. anomala* can easily be distinguished from other North Atlantic species of *Ophiacantha* (except *O. nodosa* Lyman) because it has 6 arms. Although Koehler (1914) suggested that *O. nodosa* was conspecific with *O. anomala* several differences are apparent, *O. anomala* differing from *O. nodosa* by the following characters: 1. the jaw appears narrower than *O. nodosa*; 2. the apical and oral papillae do not appear to be as long nor as widely separated from each other

5 - ARMED SPECIES



*O. bidentata*



*O. levis*

*O. aristata*

Fig. 15 Ophiacanthidae: Ophiacanthinae. *Ophiacantha*—five armed species. Captions as in Fig. 14.



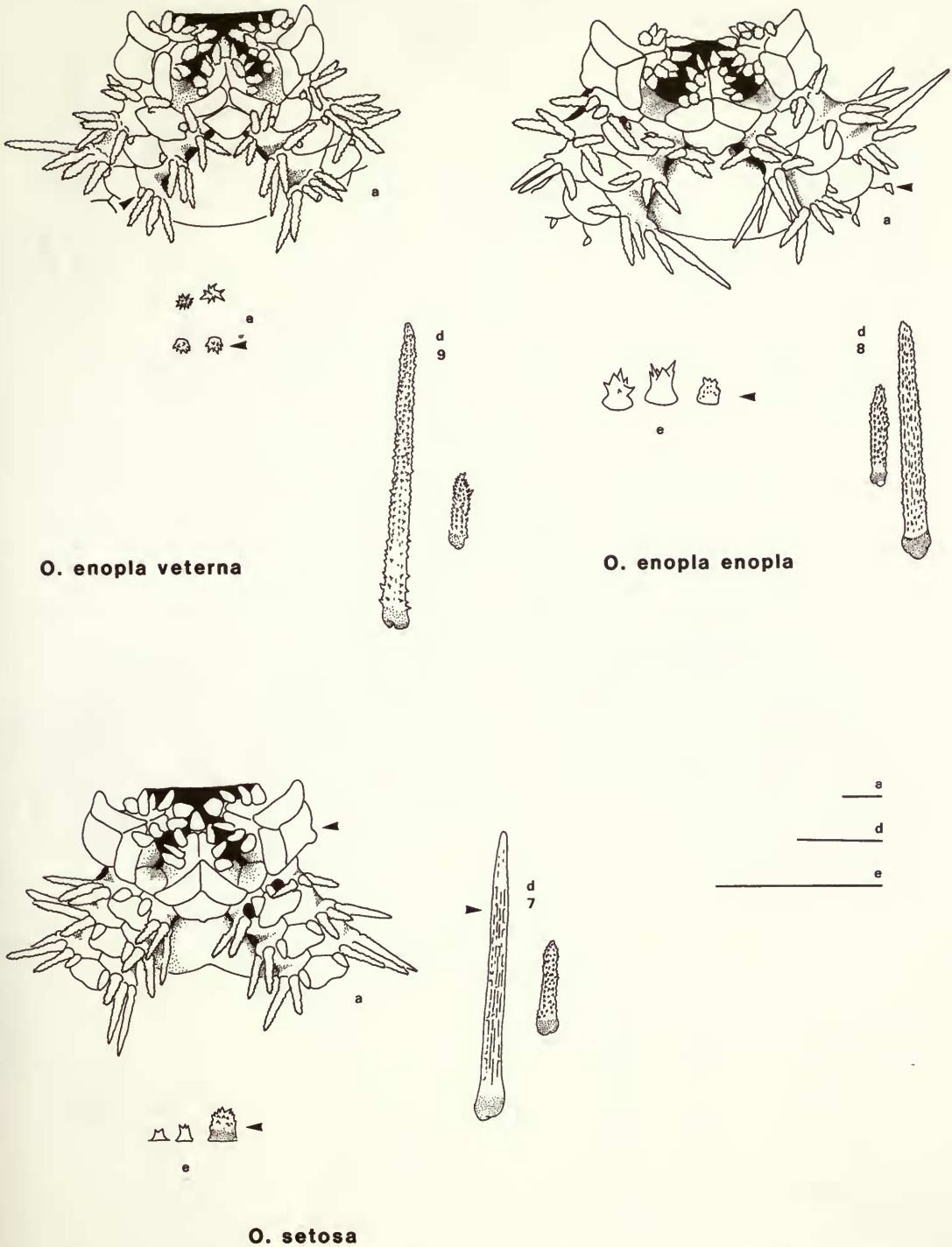
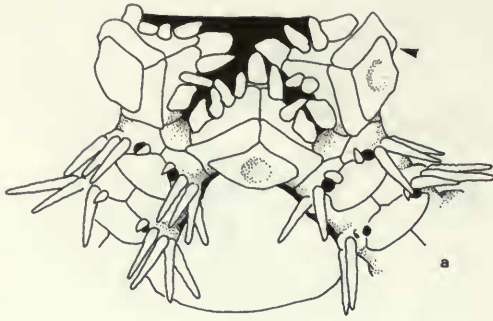
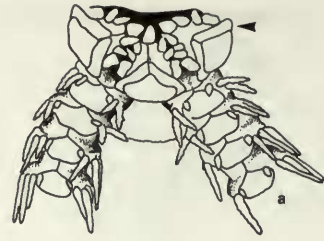


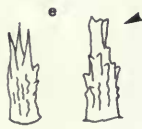
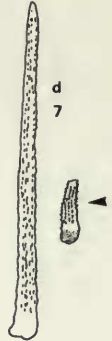
Fig. 16 Ophiacanthidae: Ophiacanthinae. *Ophiacantha*—five armed species. Captions as in Fig. 14.



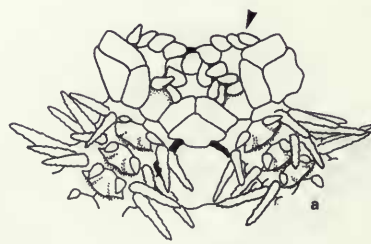
**O. aculeata**



**O. simulans**



**O. cosmica**



**O. crassidens**

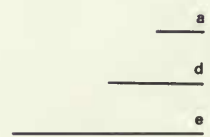
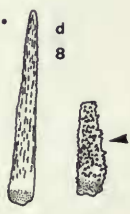
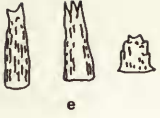
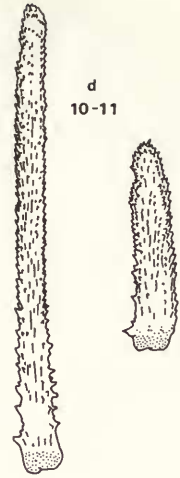
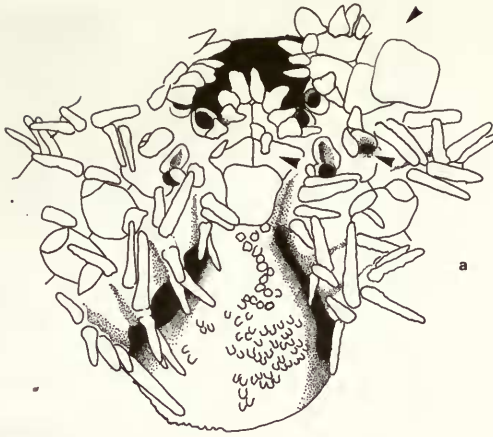
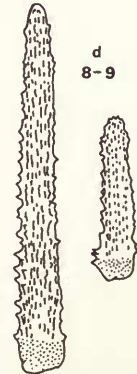
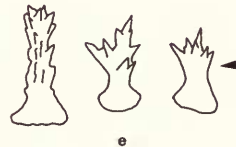
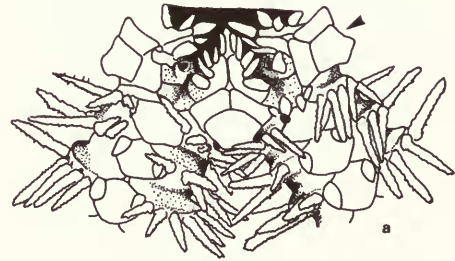
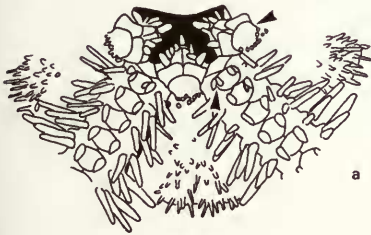
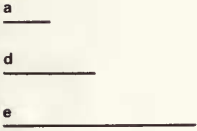


Fig. 17 Ophiacanthidae. Ophiacanthinae. *Ophiacantha*—five armed species. Captions as in Fig. 14.



**O. rosea**



**O. spectabilis**

**O. cuspidata**

**Fig. 18** Ophiacanthidae: Ophiacanthinae. *Ophiacantha*—five armed species. Captions as in Fig. 14.

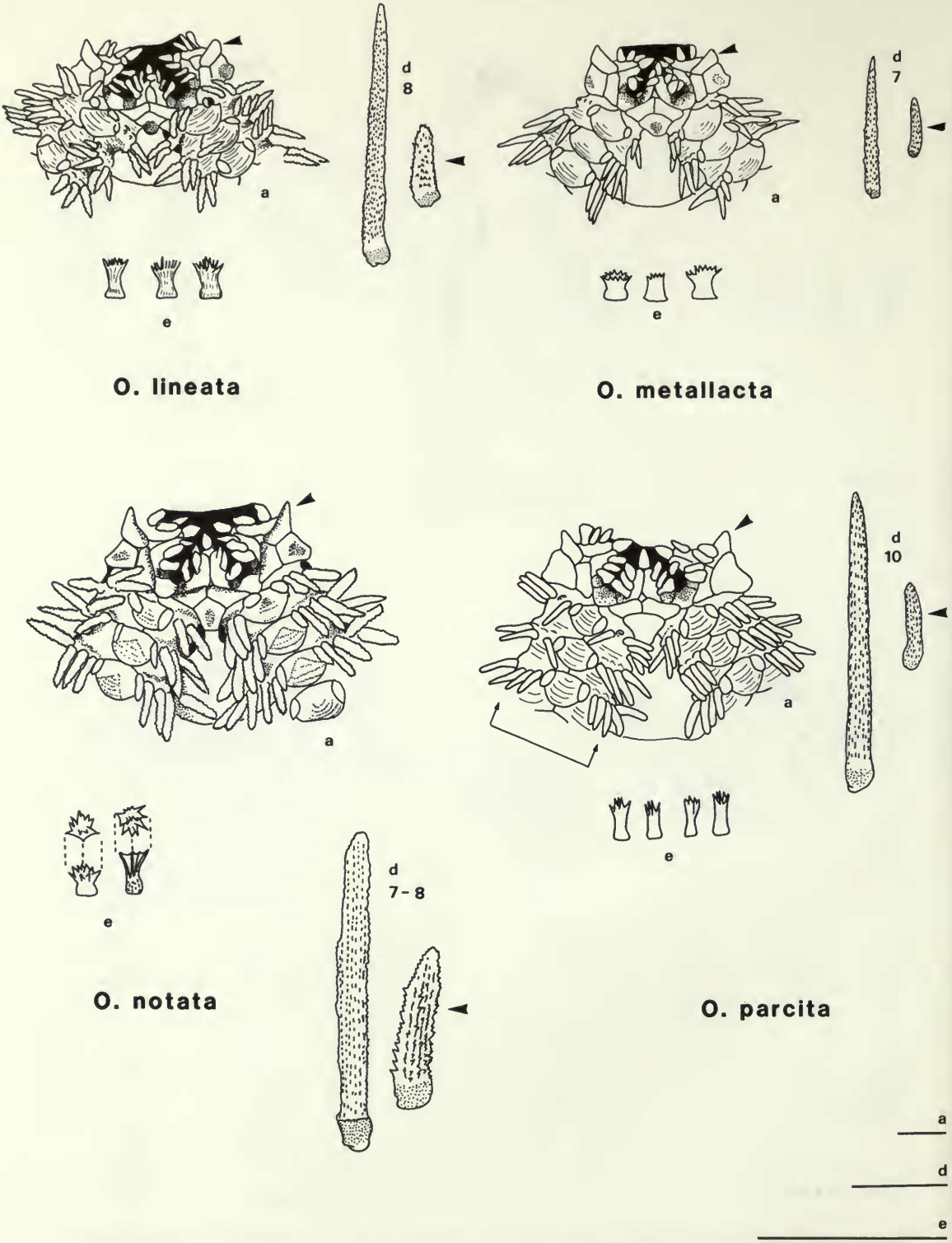


Fig. 19 Ophiacanthidae: Ophiacanthinae. *Ophiacantha*—five armed species. Captions as in Fig. 14.



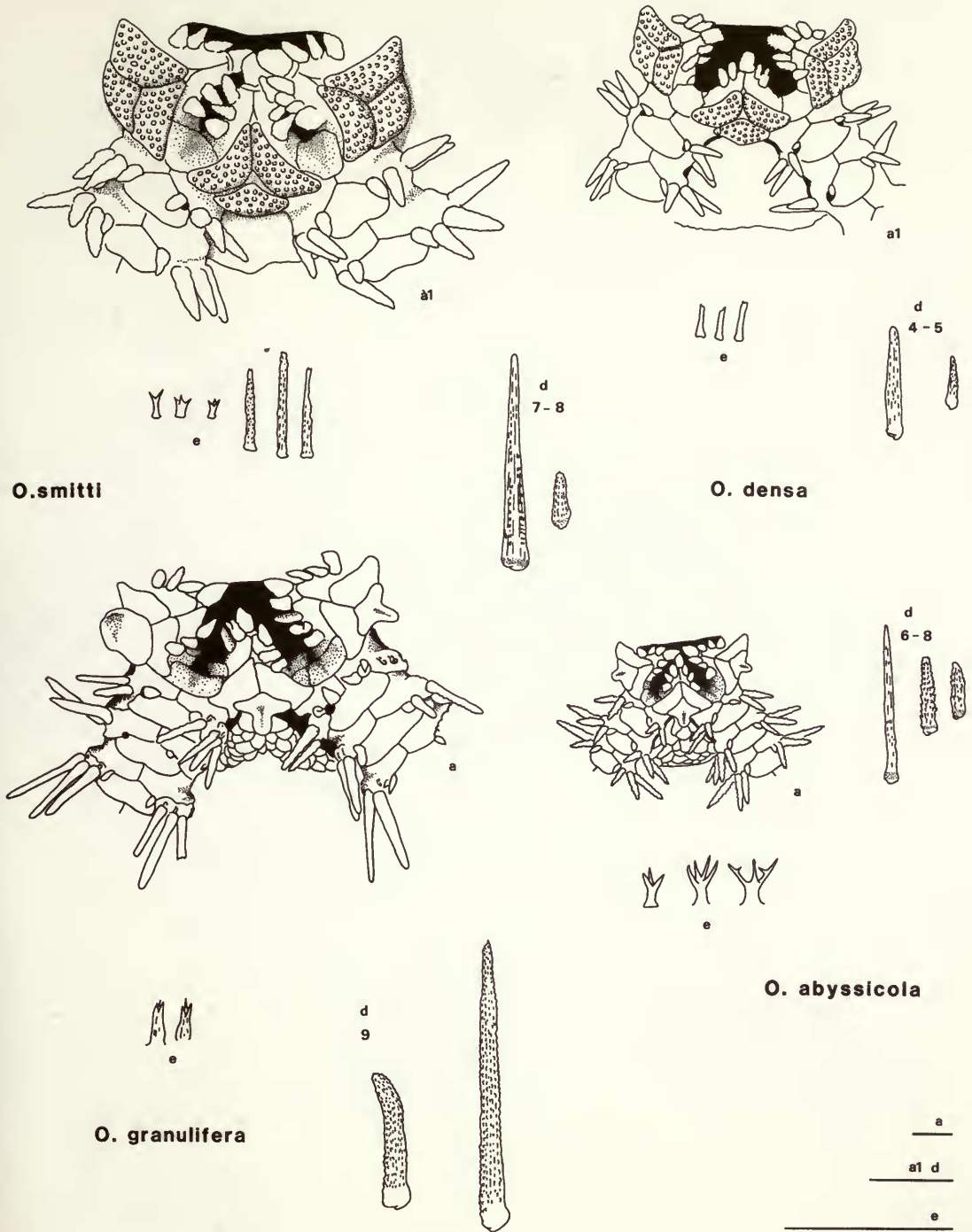


Fig. 20 Ophiacanthidae: Ophiacanthinae. *Ophiacantha*—five armed species. Captions as in Fig. 14.

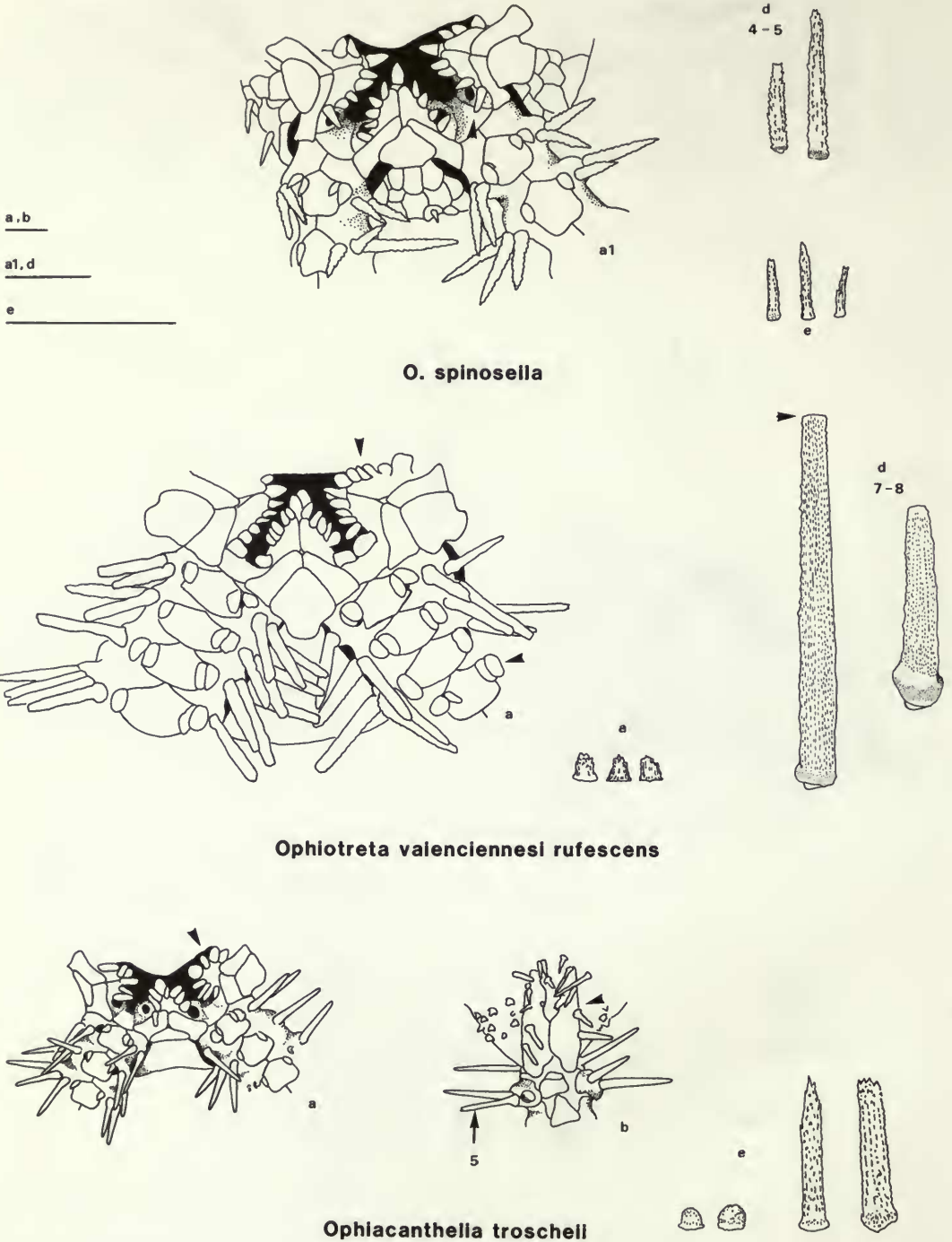
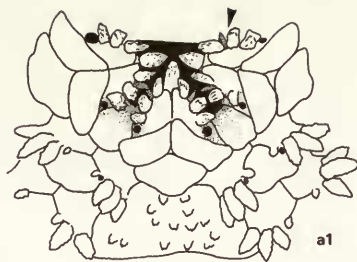
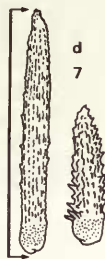
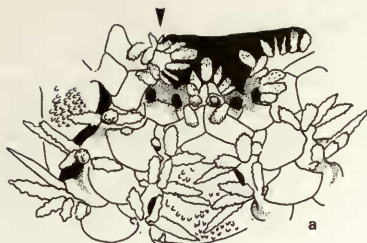
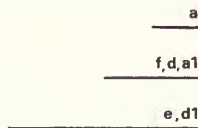
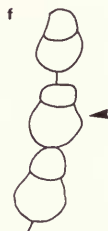


Fig. 21 Ophiacanthidae: Ophiacanthinae. *Ophiacantha*—five armed species; *Ophiotreta* and *Ophiacanthella*. Captions as in Fig. 14.

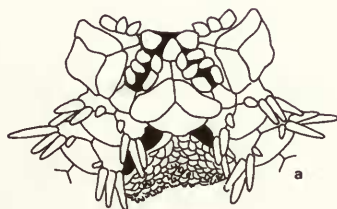


**Ophiolebes pachyphylax**

**Ophiolebes bacata**



**Ophiolebes retecta**



**Ophiacantha brevispina \***

**Fig. 22** Ophiacanthidae: Ophiacanthinae. *Ophiolebes* and supplement to *Ophiacantha*. Captions (a)–(e) as in Fig. 14; (f) dorsal arm plates, \*—not described in text.



as in *O. nodosa*; **3.** the distalmost oral papilla is often large and flap like in *O. anomala* but long and flattened like the other papillae in *O. nodosa*; **4.** the shape of the oral shields differs in *O. anomala* where it is rounded pentagonal with a rounded to obtuse proximal angle, straight lateral sides and a straight or slightly rounded distal edge, in *O. nodosa* it is a more ornate pentagonal shape with an obtuse proximal angle, slightly indented lateral sides and a rounded distal edge or one with a slight median projection; **5.** the ventral arm spines of *O. anomala* are slightly rugose with small or no secondary points along the shaft; those of *O. nodosa* have very prominent secondary points along the shaft; **6.** the ventral arm plates of *O. anomala* appear to be narrow and less axehead shaped than *O. nodosa*. Until more material of *O. nodosa* is available it would be best to treat them as distinct specimens.

**DISTRIBUTION.** It has been recorded from both sides of the North Atlantic: in the west from off Florida to SW. Iceland 141–1200 m, and in the east from Iceland, Norway and the Rockall trough 140–1500 m.

*Ophiacantha nodosa* Lyman, 1878

Fig. 14

*Ophiacantha nodosa* Lyman, 1878: 144–145; Mortensen, 1933a: 25–26.

**MATERIAL STUDIED.** BMNH: HMS *Challenger* Stn 3 25°45'N: 20°12'W 2789 m. HOLOTYPE.

This species has six arms: the disk is round, covered by tall rugose spinelets with a multipointed crown in many instances often abraded; disk diameter 5.5 mm. Only the tips of the radial shields are visible and even then they may carry spinelets. The ventral interradial area is covered by spinelets similar to those of the dorsal side.

The jaw appears long and narrow. There is one long pointed apical papilla flanked on either side by 3–4 similarly shaped apical papillae; the papillae have a slightly rugose texture and are well separated from one another. The adoral shields are about twice as long as broad not particularly wing-like and not separating the oral shield from the first lateral arm plate. The oral shield is rounded pentagonal but with a convex distal edge.

The arms are distinctly noded, the ridges carrying the arm spines being particularly prominent. The dorsal arm plates are fan shaped with an acute proximal angle and separated. The ventral arm plates are nearly pentagonal with a distinct convex distal edge textured with layers of calcite forming a concentric pattern. There is one large pointed slightly rugose tentacle scale on each pore. There are 8–9 arm spines. The ventral ones are slightly flattened and very rugose; the dorsal ones appear smooth or finely rugose. They do not quite meet midradically to form a fan on the proximal joints.

**REMARKS.** Koehler (1914) considered that *O. nodosa* was conspecific with *O. anomala* but several characters appear to separate them as detailed under *O. anomala*.

*Ophiacantha bidentata* (Retzius, 1805)

Fig. 15

*Asterias bidentata* Retzius, 1805: 33.

*Ophiocoma bidentata*: Müller & Troschel, 1842: 99.

*Ophiacantha spinulosa* Müller & Troschel, 1842: 107; Lütken, 1859: 65; Lyman, 1865: 93.

*Ophiacantha grönlandica* Müller & Troschel, 1842: 183.

*Ophiacantha bidentata*: Lyman, 1882: 186; Verrill, 1885: 545; Bell, 1892: 127; Grieg, 1893: 22; Koehler, 1896a: 79; 1896b: 212; Koehler, 1898: 55; Verrill, 1899a: 36; 1899b: 323, 335; Grieg, 1900: 267; H. L. Clark, 1901: 249; Koehler, 1901: 102; Knipovich, 1901: 1; Whiteaves, 1901: 60; Grieg, 1902: 13; 1903: 31; Michaelovskij, 1902: 533; Mortensen, 1903: 86; Michaelovskij, 1904: 174; Grieg, 1905: 159; Schmitt, 1904: 24; Koehler, 1907: 289; Kalischewskij, 1907: 19; Koehler, 1909: 184; Grieg, 1910: 5; H. L. Clark, 1911: 30; Mortensen, 1913: 358; Koehler, 1914: 80; Mortensen, 1927: 196; Grieg, 1928a: 10; 1928b: 19; Mortensen, 1932: 26; Nobre, 1931: 81; Mortensen, 1933a: 20–22; Heding, 1935: 58; Djakanov, 1954: 36–37; Grainger, 1955: 907; Tyler & Gage, 1982: 45–55; Gage *et al.* 1983: 289–290.

*Ophiacantha fraterna* Verrill, 1885: 545; Koehler, 1914: 83; H. L. Clark, 1915: 198.

**MATERIALS STUDIED.** BMNH: *Ernest Holt* Barent Sea (several localities) 24 specimens; *Porcupine* Lofoten Is Norway 37–55 m 4 specimens; *Porcupine* Stn 52 702 m 2 specimens; *Porcupine* Stn 57 805 m 2 specimens; D'Arcy Thompson Coll. off Norman's Light Labrador 1 specimen; Arctic Expedition 1875–76 Franklin Pierce Bay, N. Canada 2 specimens; *Ernest Holt* various localities around southern Greenland 24 specimens; Kara Sea 3 specimens.

**COB:** BIOGAS Stn 1: DS12 2180 m 1 specimen; DS15 2246 m 26 specimens; DS16 2325 m 4 specimens; DS17 2103 m 14 specimens; DS18 2138 m 14 specimens; DS35 2226 m 5 specimens; DS63 2250 m 1 specimen; DS64 2156 m 3 specimens; DS71 2194 m 1 specimen; CV09 2119 m 2 specimens; CV10 2108 m 9 specimens; CV20 2282 m 12 specimens; CV23 2034 m 4 specimens; CV24 2025 m 7 specimens; CV25 1985 m 1 specimen; CP01 2245 m 38 specimens; CP02 2177 m 23 specimens; CV39 2350 m 18 specimens; CP08 2177 m 11 specimens; CP26 2115 m 13 specimens; CP27 1920 m 12 specimens.

**BIOGAS Stn 2:** DS58 2775 m 1 specimen; DS74 2774 m 1 specimen CV12 2775 m 1 specimen; CV26 2822 m 1 specimen; CV40 2860 m 3 specimens; CP09 2171 m 30 specimens; CP10 2878 m 2 specimens; CP12 2925 1 specimen; CP28 3380 m 2 specimens.

**BIOGAS Stn 4:** DS23 4734 m 3 specimens; CV35 4721 m 4 specimens.

**BIOGAS Stn 6:** DS25 2096 m 4 specimens; DS26 2076 m 11 specimens; DS51 2430 m 2 specimens; DS70 2150 m 3 specimens; CV16 1909 m 1 specimen; CV32 1895 m 6 specimens; CP07 2170 m 36 specimens; CP23 1980 m 2 specimens.

**BIOGAS Stn HZ:** DS04 1100 m 1 specimen; DS14 1560 m 17 specimens; CV05 2305 m 2 specimens; CV06 2200 m 1 specimen; CW03 2160 m 2 specimens; CV11 2141 m 9 specimens.

**INCAL:** Stn WS01 50°18'N: 13°08'W 2550 m 1 specimen; Stn CP01 57°57'N: 10°55'W 2068 m 376 specimens; Stn CP02 57°58'N: 10°42'W 21 specimens; Stn CP04 56°33'N: 11°11'W 2494 m 5 specimens; Stn CP09 50°15'N: 13°16'W 2719 m 1 specimen.

**IOS:** *Discovery* Investigations: Stn 8512/4 42°15'2"N: 11°35'2"W 2281–2465 m 2 specimens; Stn 9041 1 specimen; Stn 9133/5 20°57'5"N: 18°13'7"W 1 specimen.

**SMBA:** RRS *Challenger II*. Stn ES 55 54°40'N: 12°16'W 2878 m 2 juveniles Stn ES 112 55°12'N: 15°50'W 1900 m 20 specimens; Stn AT 141 54°44'N: 12°14'W 2909 m; Stn ES 195 57°23'N: 10°27'W 2190 m 186 specimens; Stn ES 197 57°21'N: 10°29'W 104 specimens.

The disk is round, covered with an armament of spinelets or sometimes granules which obscure the scales of the disk; disk diameter up to 13 mm. The spinelets are basically trifold but may be elaborated with secondary points; in larger specimens, disk diameter greater than 7 mm, the armament has the form of rugose granules which may be abraded spinelets. The radial shields are long, thin and separated usually with only their distal ends visible. The ventral interradial areas have similar armament to the dorsal side.

The jaw is as broad as long. There is one pointed apical papilla flanked by 3–4 oral papillae, occasionally as many as 5 or 6 on each side. The oral papillae are usually pointed although distalmost ones may be slightly rectangular. The adoral shields are long and thin and barely separating, if at all, the oral shield from the first lateral arm plate. The oral shield is variable ranging from a lozenge to a flattened triangle.

The arms have a distinct noded appearance. The dorsal arm plates are fan shaped and usually separated but proximal ones may be contiguous. The ventral arm plates are pentagonal to square with a rounded or sometimes concave distal edge; they are usually separated throughout the arm. There is one scale-like scale on each tentacle pore. There are 6 to 8 finely rugose arm spines on the proximal arm segments; on distal segments the ventral spines may be flattened and have a comb-like structure along one edge.

**REMARKS.** *O. bidentata* can be distinguished from other *Ophiacantha* species by the form of the spinelets which are either rugose granules or trifold spinelets, the larger specimens usually having more abraded spinelets; the arrangement of the oral papillae; the shape of the oral shields which are basically rhombic although variable in shape; and the texture of the arm spines which are finely rugose.

*O. bidentata* is a variable species; particularly with regard to the shapes of the dorsal and ventral arm plates, the tentacle scales and the disk armament. Mortensen (1933a) considered *O. fraterna* to be a variety of *O. bidentata* apparently more commonly found in the cold water regions of the Atlantic. If such a geographical distribution holds good then *O. fraterna* should be treated as subspecies distinguished from *O. bidentata bidentata* by the nearly bell shaped dorsal arm plates which are sometimes contiguous on proximal arm segments and by the ventral arm plates which are notched on the distal edge.

Recent work by Tyler & Gage (1982) has shown that the deep sea populations have a different reproductive cycle to shallow high Arctic ones. As yet there is no morphological features which can distinguish them as separate species, except perhaps the features mentioned above but this needs to be investigated.

**DISTRIBUTION.** This is a very common Arctic and North Atlantic species. It has been recorded in the west from South Carolina north to Greenland and in the east from southern Iceland, south to



the Azores and off north Africa with a bathymetric range 32–4730 m. In the Arctic it has been recorded from Baffin Bay, Barents, Kara and Siberians Seas. It has also been recorded in the northern Pacific from the Bering Sea to off Japan.

*Ophiacantha aristata* Koehler, 1896a

Fig. 15

*Ophiacantha aristata* Koehler, 1896a: 84; 1896b: 212; 1898: 55; Farran, 1913: 43–44; Mortensen, 1927: 193–194; Grieg, 1932: 38.

MATERIAL STUDIED. MNHN: *Talisman* 1883 Stn 52 28°33'N: 15°39'W 946 m 5 specimens.

IOS: *Discovery* Investigations: Stn 8519/7 24°02'N: 16°59'W 997–1037 m 2 specimens; Stn 8967 31°25-9'N: 10°53-7'W 8 specimens; Stn 9042 42°15'N: 11°22'W 1662–1541 m 5 specimens.

DM: Irish Fisheries *Helga* S.R. 477 51°15'N: 11°47'W 1272–1278 m 1 specimen.

The disk is round, covered with spinelets, disk diameter up to 8 mm. The spinelets are crowned with 9 or more points which may be subdivided into secondary points giving the crown a very irregular appearance. The radial shields are sometimes inconspicuous but in some specimens their distal ends may be distinguishable. The ventral interradial areas are covered with spinelets similar to those of the dorsal side.

The jaws are as broad as long. There is one pointed apical papilla flanked on each side by 3–4 rugose oral papillae, although in some specimens there may be more giving the appearance of a double row. The oral papillae are longer than broad and may be widened at their free end. The adoral shields are longer than broad separating the oral shield from the first lateral arm plate. The oral shield is approximately rhombic sometimes with the distal edge slightly produced.

The arms are distinctly noded. The dorsal arm plates are triangular to fan shaped and separated from one another. The ventral arm plates are pentagonal to nearly rectangular with a convex distal edge, and are separated from one another. There is one highly rugose spine-like tentacle scale on each tentacle pore. There are 8–9 highly rugose arm spines proximally, the dorsal most is the longest equal to 3 arm segments; on proximal joints the arm spines may meet in the midradial line forming a single fan.

REMARKS. *O. aristata* may be confused with *O. bidentata*, particularly juveniles. It can be separated from *O. bidentata* by the following characters; the spinelets of the disk have more points and are more irregular; the arm spines are highly rugose and the tentacle scale is also rugose and spine-like while that of *O. bidentata* is small, flat and scale-like.

DISTRIBUTION. *O. aristata* has only been recorded from the north-east Atlantic: from the Canary Islands north to SW. Ireland with a bathymetric range of 822–1700 m.

*Ophiacantha enopla enopla* Verrill, 1885a

Fig. 16

*Ophiacantha enopla* Verrill, 1885a: 153; 1899a: 37, 42; 1899b: 331.

MATERIAL STUDIED. USNM: *Fish Hawk* Stn 1124 40°01'N: 68°54'W off Martha's Vineyard 1152 m SYNTYPE.

The disk is round to subpentagonal, up to 11 mm in diameter; and is covered with stubby spinelets with an irregular crown of many points. The radial shields are not visible. The ventral interradial areas are also covered with spinelets which are more nearly granular than those of the dorsal side.

The jaws are as broad as long. The single spineform apical papilla is flanked by 6 or more rugose, often blunt and peg-like oral papillae which are irregularly arranged on each side. The adoral shields are large but do not separate the oral shield from the first lateral arm plate. The oral shield is rhombic often with the two proximal sides indented.

The arms are slightly noded. The dorsal arm plates are triangular to fan shaped; the first 2–3 dorsal arm plates may be contiguous. The ventral arm plates are pentagonal with a rounded distal edge, proximal plates are contiguous or nearly so. There is one small rugose tentacle scales on each tentacle pore. There are proximally 8 slightly rugose arm spines, the second dorsalmost one the largest, equal in length to 3 segments. The proximal arm spines do not form a fan.

REMARKS. The similarity of this western Atlantic subspecies to its eastern counterpart is dealt with under the REMARKS section of *O. enopla veterna*.



DISTRIBUTION. *O. enopla enopla* has so far only been recorded from SE. of Cape Cod at a depth of 1152 m.

*Ophiacantha enopla veterna* (Koehler, 1907b)

Fig. 16

*Ophiacantha veterna* Koehler, 1907b: 41; 1909: 189; Mortensen, 1927: 187.

MATERIAL STUDIED. COB: BIOGAS Stn 6: CP07 2170 m 1 specimen; CP23 1980 m 1 specimen. BIOGAS Stn 1: CV10 2108 m 2 specimens; CP01 2245 m 1 specimen; CP02 2177 m 4 specimens.

IOS: Discovery Investigations: Stn 8005 22°29'N: 17°14'W 101 m 1 specimen, Stn 9042 42°15'N: 11°22'W 1662–1541 m 48 specimens.

The disk is round to subpentagonal covered by low granules which have a rugged crown of many small points, disk diameter up to 11 mm. Often the whole length of the radial shields is visible and they may be bowed upwards in some specimens. The ventral interradiial areas are also covered with granules although perhaps not as densely as the dorsal surface.

The jaws appear to be as broad as long. There is one pointed slightly rugose apical papilla usually flanked by 4 oral papillae on each side but frequently there are also irregularly arranged papillae. The oral papillae are blunt conical and rugose. The adoral shields are long and narrow and do not separate the oral shield from the first lateral arm plate. The oral shield is pentagonal to lozenge shaped, with the 2 proximal sides indented and the distal sides convex.

The arms are only slightly noded. The dorsal arm plates are fan shaped to bell shaped and separated. The ventral arm plates are pentagonal and separated. The tentacle pores are small with 'spine-like' scales on the first and second arm pores but subsequently become very much smaller and are absent on distal pores. Proximally there are 9 arm spines, distally 7. The dorsal arm spines are smooth to finely rugose with large secondary points along the shaft, the ventralmost spines are highly rugose. The proximal arm spines approach midradially but do not form a single fan.

REMARKS. *O. enopla veterna* is characterised by the many rugose oral papillae and the low rugose granules. *O. enopla veterna* differs from *O. enopla enopla* chiefly by the shapes of the disk spinelets and the tentacle scales; the spinelets appear to be larger in *O. enopla enopla* and have a better defined crown with distinct points. The tentacle scales of *O. enopla enopla* are small and rugose while those of *O. enopla veterna* are very small and missing distally. These characters are not of sufficient weight to warrant maintaining *O. enopla* as a separate species.

DISTRIBUTION: *O. enopla veterna* has been recorded only from the eastern Atlantic from the Bay of Biscay south to the Azores and Madeira, with a bathymetric range of 101–2245 m.

*Ophiacantha setosa* (Retzius, 1805)

Fig. 16

*Asterias setosa* Retzius, 1805: 30.

*Ophiacantha setosa*: Müller & Troschel, 1842: 106; Marenzeller, 1893: 12; Koehler, 1892: 414; 1896b: 212; 1898: 12; 1906: 6; 1907: 291; Gallo, 1926: 19; Nobre, 1931: 83; Cherbonnier, 1962: 5–6; Madsen, 1970: 161.

MATERIAL STUDIED. BMNH: Rad Nord and South of the Rion, off Marseille 60–110 m 7 specimens.

The disk is round, sometimes indented interradiially, diameter up to 12 mm. The disk is covered with scales which may be obscured by thickened skin. Low granules are found sporadically over the disk, slightly larger ones in the vicinity of the radial shields. Usually only the tips of the radial shields are visible but in some specimens a large distal portion of the shield may be visible. The ventral interradiial area is covered by scales slightly larger than those of the dorsal side, few bearing granules.

The jaws are as long as broad. There is a stout pointed apical papilla flanked by 3 pointed oral papillae on each side. The adoral shields are slightly convex; they do not separate the oral shield from the first lateral arm plate. The oral shield is rhombic sometimes with a distinct distal lobe.

The arms are slightly noded. The dorsal arm plates are bell shaped; all are separated. The ventral arm plates are slightly rectangular with a convex distal edge which in some specimens may have a median concave indentation. The tentacle pores are large. The basal part of the tentacle itself appears to be reinforced with calcite and resembles a tube out of which the distal part of the tentacle projects. There is one rather large rugose pointed tentacle scale on each tentacle pore. There are 7 arm spines proximally, 6

distally, forming a fan over the arms on the proximal points. The dorsal arm spines are long and glassy often with sharp secondary points on the shaft. The dorsal or second dorsalmost spine is the longest, up to 3 arm segments long. The ventral arm spines are highly rugose.

REMARKS. *O. setosa* is recognisable by the skin covering of the disk, the low density of granule-like armament, the shape of the oral shield and the glassy arm spines.

DISTRIBUTION. *O. setosa* has been recorded from the Mediterranean and the Eastern Atlantic, as far north as the Bay of Biscay, and south to Angola. Most records come from shelf or bathyal depths, 50–1480 m.

*Ophiacantha cosmica* Lyman, 1878

Fig. 17

*Ophiacantha cosmica* Lyman, 1878: 146; 1882: 194–195; Koehler, 1909: 611; Clark, 1939: 42; Tommasi, 1970: 17.

MATERIAL STUDIED. BMNH: HMS *Challenger* Stn 157 53°55'S: 108°35'E 3566 m HOLOTYPE & 2 PARATYPES.

The disk is round, diameter up to 19.5 mm; covered by a dense coating of long rugose spinelets with basically a trifold crown. The radial shields are usually covered although in some specimens it is possible to see the outline of distal end. The ventral interradial areas are also covered by spinelets which are slightly smaller than those of the dorsal side.

The jaws appear wider than long. There is one large broad apical papilla which sometimes lies within the mouth slit. Several papillae may lie above it. It is flanked by 3–4 large pointed oral papillae each side, of which the distalmost is the largest. In addition to these papillae there may be several supernumerary papillae situated on the edge of the jaw and on the edge of the adoral shields, but they are less common in smaller specimens. The adoral shields are wide and distinctly wing-like, separating the oral shield from the first lateral arm plate. The oral shield is somewhat variable in shape but is basically a rounded rhombic or triangular shape, the distal edge being more or less flattened or convex.

The arms are not distinctly noded proximally. The dorsal arm plates are fan shaped not or only just contiguous proximally, separated distally. The ventral arm plates are wider than long, pentagonal or nearly triangular with a wide distal edge which may be slightly indented; all are separated. There is one small pointed tentacle scale on each pore. There are 9 arm spines proximally, 7–8 distally in large specimens, 6–8 on smaller ones. The arm spines are finely rugose with occasional larger points, the second or third dorsalmost ones which are often up to 2 arm segments long. In some specimens the arm spines form a fan on the proximal arm segment.

REMARKS. This species may be recognised by the long rugose disk spinelets, the large apical and oral papillae, and the large adoral shields.

DISTRIBUTION. *O. cosmica* has a widespread distribution being recorded from the Atlantic, Indian and Pacific Oceans. In the North Atlantic it has only been recorded from south of Martha's Vineyard in 2509 m.

*Ophiacantha aculeata* Verrill, 1885a

Fig. 17

*Ophiacantha aculeata* Verrill, 1885a: 153; 1899a: 32; 1899b: 323, 335; Mortensen, 1933a: 28–29; Gage *et al.* 1983: 291.

MATERIAL STUDIED. COB: BIOGAS Stn 2: DS41 3548 m 7 specimens; CP11 3056 m 35 specimens; CP28 3380 m 80 specimens.

IOS: *Discovery* Investigations: Stn 7711/8 53°09'8"N: 20°14'7"W 2425–2430 m 3 specimens. 'Knorr' cruise Stn 35 39°10'N: 71°35'W 2 specimens.

SMBA: RRS *Challenger II*: Stn SWT 13 52°04'N: 16°09'W 3463 m 1 specimen.

The disk is round, to slightly pentagonal, diameter up to 13 mm; covered by trifold spinelets, rarely the spinelets may be more elaborate but often the crown is indistinct and the spinelets appear to be rugose. Only the tips of the radial shields are visible although the extent of the shield can be discerned beneath the scales of the disk. The ventral interradial areas are also covered with spinelets.



The jaw appears broader than long. There is one large often blunt apical papilla flanked by 3 oral papillae on each side, the two proximal ones are large and pointed, the distalmost one is block-like. The adoral shields are large with lateral projections making them appear wing-like; they separate or appear to separate the oral shield from the first lateral arm plate. The oral shield is basically rhombic but in some specimens the distal lobe is produced and the plate becomes arrow shaped. There may be a slight depression in the centre of the shield.

The arms are slightly noded becoming distinctly so distally. The dorsal arm plates are fan to bell shaped and separated. The ventral arm plates are pentagonal with a wide distal edge and are separated from one another. In some specimens there are indications of transverse ridges on the edge of these plates and also on the lateral arm plates. The tentacle scale is pointed and spine-like; on a few specimens there are two tentacle scales on the first arm segment. There are 7 finely rugose arm spines proximally, 4-5 distally; there are large secondary points on the shaft of some spines. The arm spines form a fan on the proximal arm joint.

**REMARKS.** This species is very similar to *O. simulans* but differs in the following respects: it appears to reach a much larger size; the spinelets of the disk are less elaborate and have fewer points to the crown; the shape of the oral shield differs and is depressed in *O. aculeata*; the adoral shields are more wing-like and separate the oral shield from the first lateral arm plate; the arm spines are less rugose particularly the proximal ventral spines; and finally the ventral most arm spine is not so distinctly sabre shaped as in *O. simulans*.

**DISTRIBUTIONS.** *O. aculeata* has been recorded in the west Atlantic from off Virginia at depths of 2500-2539 m and in the east from the Rockall Trough, the Bay of Biscay and the Iberian Basin at depths of 3425-3584 m.

***Ophiacantha simulans* Koehler, 1896a**

Fig. 17

*Ophiacantha simulans* Koehler, 1896a: 82; Mortensen, 1933a: 26-29; Gage *et al.* 1983: 291.

*Ophiacantha composita*: Koehler, 1907: 289-290; Mortensen, 1927: 191; (non *O. composita* Koehler, 1904).

**MATERIAL STUDIED.** MNHN: *Travailleur & Talisman* 1882 Stn 13 44°7'N: 10°16'W 2030 m 5 specimens.

**COB:** BIOGAS Stn 1: DS11 2205 m 1 specimen; DS15 2246 m 13 specimens; DS17 2103 m 6 specimens; DS18 2138 m 8 specimens; DS17 2103 m 6 specimens; DS65 2360 m 2 specimens; CV08 2180 m 6 specimens; CV09 2119 m 4 specimens; CV10 2108 m 2 specimens; CV23 2034 m 2 specimens; CV24 2025 m 1 specimen; CV25 1985 m 2 specimen; CV01 2245 m 9 specimens; CP02 2177 m 22 specimens; CV39 2350 m 4 specimens; CP09 2171 m 11 specimens; CP10 2878 m 3 specimens. BIOGAS Stn 3: CV28 4032 m 1 specimen. BIOGAS Stn 6: CV32 1895 m 1 specimen; CP07 2170 m 3 specimens; CP23 1980 m 1 specimen. BIOGAS Stn HZ: CW03 2160 m 1 specimen; CV11 2141 m 5 specimens.

**IOS:** *Discovery* Investigations: Stn 8512/4 42°15-2'N: 11°35-2'W 2281-2465 m 1 specimen.

**SMBA:** RRS *Challenger II*: Stn ES 112 55°12'N: 15°50'W 1900 m 26 specimens.

The disk is round, diameter up to 10 mm, covered with a dense coating of spinelets each crowned with 7-8 points. The radial shields are long and narrow with only their distal ends visible. Only the distal part of each ventral interradial area is covered with spinelets.

The jaws are as long as broad. There is a single pointed apical papilla flanked on each side by 3 sometimes 4 oral papillae; the distalmost of which is distinctly block-like. The proximal corner of this papilla may be produced into a point. In a few specimens this papillae may be partially divided giving the appearance of being two papillae. The adoral shields are large prominent about twice as long as broad and only just separating the oral shield from the first lateral arm plate. The oral shield is rhombic with a convex distal edge.

The arms are slightly noded. The dorsal arm plates are fan shaped and separated. The ventral arm plates are pentagonal, broader than long and separated. The tentacle scale is small and scale-like. There are 7 rugose arm spines proximally, 5 distally; the dorsalmost is the longest often up to 3 arm segments long on proximal segments. On the proximal arm segment the arm spines meet midradially forming a single fan. The ventralmost arm spine may be curved or sabre shaped.

**REMARKS.** *O. simulans* is similar to *O. aculeata* Verrill and the West Indian species *O. mesembria* H. L. Clark. The differences between *O. simulans* and *O. aculeata* are dealt with under *O. aculeata*. *O. simulans* differs from *O. mesembria* in the form of the disk spinelets which have more points to the crown than those of *O. mesembria*; shorter more rounded tentacle scales; and stout, often curved lower arm spines, those of *O. mesembria* being long and quite rugose but not curved.

**DISTRIBUTION.** This species has been recorded from both sides of the Atlantic: in the west from off the Carolinas and in the east from Iceland south of the Azores in depths of 1575–3018 m.

*Ophiacantha levis* comb nov.

Fig. 15

*Ophiomitrella levis* Koehler, 1914: 105.

**MATERIAL STUDIED. MCZ:** *Albatross* Stn 2666 30°47'N: 79°49'W off Fernandina, Florida 486 m HOLOTYPE.

The disk is round, diameter up to 5 mm; covered by a dense coating of spinelets with widened multipointed crowns. Only the distal edge of the radial shields are visible. The ventral interradial area are also coated with multipointed spinelets like those of the dorsal surface.

The jaws appear as wide as long. There is usually one large blunt apical papilla, flanked on each side by 3 spine-like oral papillae. The adoral shields are large, slightly convex and situated totally proximal to the oral shield not separating it from the first lateral arm plate. The adoral shields have glassy concretions embedded within the matrix of the plate. The oral shield is slightly pentagonal with an acute proximal angle and a slightly convex distal edge.

The arms appear noded. The dorsal arm plates are fan shaped to bell shaped and not contiguous. The ventral arm plates are wide, pentagonal, with an obtuse proximal angle and convex distal edge, which may sometimes be medianly indented; they are separated from one another. The tentacle pores are small, each is armed with a small slightly pointed tentacle scale. There are 8–9 arm spines on proximal arm segments, 6 on distal ones; dorsal arm spines are quite smooth while ventral ones are flattened and slightly sabre shaped with a toothed proximal edge. The second dorsalmost spine is the longest, up to 2 arm segments long. The arm spines form a fan on proximal arm segments.

**REMARKS.** *O. levis* is now transferred to *Ophiacantha* from *Ophiomitrella* because the radial shields are thin and rib-like not integrating with the plates of the disk like *Ophiomitrella* species and the disk is covered with fine scales. *O. levis* can be distinguished from other *Ophiacantha* species by the shape of the disk spinelets, large curved adoral shields, small pentagonal oral shield, wide ventral arm plates, and the shape of the ventral arm spines.

**DISTRIBUTION.** This species has only been recorded from the tropical western Atlantic off Fernandina, Florida 486 m.

*Ophiacantha crassidens* Verrill, 1885

Fig. 17

*Ophiacantha crassidens* Verrill, 1885: 152; 1899a: 38; 1899b: 325; Farran, 1913: 42; Grieg, 1932: 38; Mortensen, 1927: 192–193; Gage *et al.* 1983: 291.

*Ophiacantha decipiens* Koehler, 1906: 22; 1907: 283–284.

**MATERIAL STUDIED. BMNH:** 'Knorr' cruise 35 stn 311 39°19'N: 72°00'W 1 specimen.

**MNHN:** *Travailleur & Talisman* Stn 127 15 août 1883 38°38'N: 30°41'W 1257 m HOLOTYPE of *O. decipiens*.

**COB:** BIOGAS Stn 1: DS16 2325 m 1 specimen; CV10 2108 m 1 specimen; CV23 2034 m 1 specimen; CP27 2115 m 2 specimens; CV34 1970 m 16 specimens. BIOGAS Stn 6: CV16 1909 m 1 specimen. BIOGAS Stn HZ: CV11 2141 m 1 specimen.

**SMBA:** RRS *Challenger II*: Stn AT 192 57°21'N: 12°02'W 1862 m 6 specimens.

The disk is round, diameter up to 14 mm, covered by small imbricating scales, each of which may carry a single rod-like spinelet, the tip of which may be multifid or simply abraded. Only the tips of the radial shields are visible. The ventral interradial areas are covered by scales and spinelets similar to those of the dorsal surface.

The jaws appear to be slightly wider than long. The apical papilla is large, flattened and leaf shaped, flanked on either side by 3 similarly shaped oral papillae. The adoral shields are large, not separating the oral shield from the first arm plate. The oral shield is rounded, triangular often with the lateral sides indented.

The arms are not distinctly noded. The dorsal arm plates are small, triangular and separated along the length of the arm. The ventral arm plates are pentagonal to broadly triangular with a convex distal edge



which is often raised up in proximal segments. They are nearly contiguous proximally and separated distally. The tentacle scale is stout, spine-like with a blunt tip. There are 8 arm spines proximally, 6 distally, the dorsalmost of which are smooth and rounded while the ventral ones are flattened with a comb-like proximal edge.

REMARKS. *O. crassidens* is easily distinguished by the shape of the mouth and oral papillae, the low density of the rod-like spinelets and the two forms of the arm spines. The author has compared the type of *O. decipiens* with the other specimens of *O. crassidens* and could find no significant differences, and concludes that they are conspecific.

DISTRIBUTION. This species is recorded on both sides of the North Atlantic; in the west off Cape Hatteras at a depth of 1570 m, and in the east from SW. Ireland south to the Azores in depths of 980–3120 m.

*Ophiacantha spectabilis* G. O. Sars

Fig. 18

*Ophiacantha spectabilis* G. O. Sars, 1871: 10; Verrill, 1885a: 152; Bell, 1892: 128; Grieg, 1893: 24; Koehler, 1896a: 80–81; Verrill, 1899a: 38; 1899b: 335; Grieg, 1902: 14; 1905: 159; 239–740; Koehler, 1924: 246; Mortensen, 1927: 191; 1933a: 33–34; Djakanov, 1954: 40.

MATERIAL STUDIED. BMNH: Bodo, Lofoten Is 184 m 1 specimen; Triton West of Wyville-Thompson Ridge 789–515 m 2 specimens; Rodberg, Trondheim Fjord 450–710 m 1 specimen.

The disk is round, slightly indented over the arms, diameter up to 14 mm, covered by rod-like spinelets which are slightly rugose often with a narrow trifid crown. The spinelets are largest in the centre of the disk becoming shorter and more rugose towards the edge. The radial shields are not distinct. The ventral interradial areas are also covered with spinelets although the extent and density of covering varies.

The jaws have the appearance of being short and wide. There is one pointed apical papilla flanked on each side by 4 pointed slightly rugose oral papillae; Mortensen (1927) reports that there may be as many as 8 each side. The adoral shields are nearly rectangular and situated almost entirely proximal to the oral shield not separating it from the first lateral arm plate. The oral shield is oval to rounded pentagonal with the distal edge fringed by granules or low spinelets.

The dorsal arm plates are fan to bell shaped not contiguous sometimes with a finely rugose distal edge. The ventral arm plates are pentagonal with a convex distal edge and an obtuse proximal angle, separated or only just contiguous; in some specimens the plate boundaries are obscured by skin but this is not a constant feature. The tentacle pores are large; the tentacle scales are large leaf shaped and there are two on the first arm pore and sometimes also on the second. There are 7–8 finely rugose and flattened arm spines proximally 5–6 distally; not forming a fan on the proximal arm joints. The dorsal or second dorsalmost spine is the longest often up to three arm segments in length.

REMARKS. *O. spectabilis* appears to have a close affinity with *O. rosea*. Both have a similar jaw structure, position of the adoral shields, and shape of the ventral arm plates and tentacle scales. They differ in the shape of the oral shield which is nearly rectangular in *O. rosea* but more pentagonal in *O. spectabilis*, also the distal edge of the oral shield in *O. spectabilis* is fringed with papillae. *O. rosea* commonly has supernumerary papillae on the jaw which are rare or absent in *O. spectabilis*. Finally the tentacle pores are usually larger in *O. rosea* and the first arm pore may have 3 tentacle scales.

DISTRIBUTION. *O. spectabilis* is found on both sides of the North Atlantic: in the west it has been recorded from off Nova Scotia at the depth of 238 m, while in the east it has been found south of Iceland, Norway, SW. Ireland south to the Bay of Biscay in the depths of 145–1700 m.

*Ophiacantha cuspidata* Lyman, 1878

Fig. 18

*Ophiacantha cuspidata* Lyman, 1878: 143; 1882: 191; Verrill, 1899a: 42; Koehler, 1909: 186; Mortensen, 1927: 189; 1933a 31–33; Gage *et al.*, 1983: 291.

MATERIAL STUDIED. BMNH: HMS *Challenger* Stn 344 off Ascension Island 768 m HOLOTYPE & 3 PARATYPES.

**COB:** *Cymor* 47°44'N: 8°21'W 2420 m 2 specimens.

**IOS:** *Discovery* Investigations: Stn 9042 42°15'N: 11°22'W 1662–1541 m 5 specimens.

**SMBA:** RRS *Challenger II*: Stn ES 112 55°12'N: 15°50'W 1900 m 2 specimens.

The disk is round, diameter up to 10 mm, covered by large rugose spinelets often with elaborate multi-pointed crowns. The tips of the radial shields are sometimes visible and it is usually possible to see the extent of the shields beneath the disk scales. The ventral interradial areas are covered by spinelets similar to the dorsal side although they are usually smaller and in some specimens they may resemble rugose granules.

The jaws appear to be slightly longer than wide. There is one long pointed apical papilla flanked on each side by 3–5 long thin oral papillae the distalmost of which may have the free end enlarged. The adoral shields are short, rectangular in shape, they do not or only just separate the oral shield from the first lateral arm plate. The oral shield is a rounded pentagonal with an obtuse or slightly rounded proximal angle. The distal part of the shield may be indented.

The arms are not markedly noded. The dorsal arm plates are triangular with a convex distal edge and separated. In some specimens the distal edge may be raised up often with many small spikes. The ventral arm plates are rounded pentagonal with a rounded, nearly pointed, distal edge and are contiguous. There are two, occasionally three, large flat tentacle scales on the first tentacle pore subsequent pores have only one. There are 8–9 slightly rugose arm spines of which the ventral spines are the most rugose. The second or third dorsalmost spine is the longest, up to 3 arm segments long. On the proximal arm segment the arm spines form a fan.

**REMARKS.** *O. cuspidata* appears to have an affinity with *O. lineata*, *O. metallacta* and *O. parvita*. It can be distinguished by the form of the disk armament, the shape of the oral shield and the lack of transverse striations on the ventral and lateral arm plates (see Table 1).

**DISTRIBUTION.** *O. cuspidata* has been recorded in the eastern Atlantic from Iceland as far south as Ascension Island with a bathymetric range of 768–2460 m.

### *Ophiacantha lineata* Koehler, 1896c

#### Fig. 19

*Ophiacantha lineata* Koehler, 1896c: 247; 1909: 187–188; 1914: 87; 1921: 4; Cherbonnier & Sibuet, 1972: 1366.

**MATERIAL STUDIED.** **MOM:** *Princesse Alice* Stn 578 1895 38°26'N: 26°30'45"W 1165 m 3 SYNTYPES.

**MNHN:** *Princesse Alice* Stn 3140 37°38'N: 26°01'W 1378 m. 1 specimen.

**COB:** *Cymor* 2 DR 29 48°19'N: 11°57'W 1470 m. 1 specimen.

The disk is round, up to 6 mm diameter covered by spinelets with a crown of many points, 9 or more, the spinelets may extend on to the dorsal part of the arm. Only the distal ends of the radial shields are visible. The ventral interradial areas are covered by spinelets similar to the dorsal side.

The jaws are as wide as long. The oral plates are often distinctly bowed meeting only at their proximal ends. There is one pointed apical papilla flanked on each side by 3–5 oral papillae, the distalmost of which is long and rectangular. The adoral shields are about 2–3 times as long as broad, wing-like, not separating the oral shield from the first lateral arm plate. The oral shield is irregular in shape, the proximal edge is rounded and the distal edge may be produced and this region may be depressed; in some specimens the oral shield looks pentagonal, again with the distal portion depressed.

The arms are distinctly noded. The dorsal arm plates are triangular and nearly contiguous. The ventral arm plates are pentagonal with the distal edge rounded and contiguous at least proximally. The tentacle scale is rugose and pointed. The lateral and ventral arm plates have distinctive transverse ridges most noticeable in dry or nearly dry specimens. There are 8 rugose arm spines, many are distinctly curved. The dorsalmost arm spines are the longest up to 4 arm segments in length.

**REMARKS.** The transverse ridges are a distinctive feature which separates this species from many other North Atlantic species, other species with this feature are *O. parvita*, *O. metallacta*, *O. notata* (see Table 1) and *Ophiolimna bairdi* (Lyman). *Ophiolimna bairdi* can easily be distinguished from *O. lineata* by a number of features: the disk is covered with granules, not spinelets; which extend on to the oral frame; the oral shield is a large triangle and the oral papillae have a different shape and arrangement (see p. 60)

**Table 1** Comparison of *Ophiacantha cuspidata*, *O. lineata*, *O. metallacta*, *O. notata* and *O. parcita*

CHARACTERS	SPECIES				
	<i>O. cuspidata</i>	<i>O. lineata</i>	<i>O. metallacta</i>	<i>O. notata</i>	<i>O. parcita</i>
Disk spinelets	elongated rugose shank, elaborated trifold crown	smooth shank, wide multipointed crown	smooth shank, wide crown with elaborated points	smooth shank, wide crown with elaborated points	smooth shank, narrow multipointed crown
Adoral shields	nearly rectangular	curved winglike	curved winglike	angular winglike	rounded, nearly straight proximally
Oral shields	rounded pentagonal	irregularly shaped rounded with a distal projection	rounded rhombic, nearly pentagonal	angular pentagonal	rounded, light-bulb shape
Arms outline shape	not noded	distinctly noded	slightly noded	distinctly noded	flattened, not noded
Transverse ridges on VAP & LAP	No	Yes	Yes	Yes	Yes
Arm spine no.	8-9	8	7	7-8	10
Arm spine; texture	dorsally finely rugose; ventrally distinctly rugose	curved; rugose	finely rugose	dorsally finely rugose; ventrally very rugose	short; finely rugose



DISTRIBUTION. *O. lineata* has been recorded from both sides of the Atlantic; in the west it has been recorded off Florida 511–792 m and in the east off the Azores and in the Bay of Biscay 1165–1378 m.

*Ophiacantha metallacta* H. L. Clark, 1915

Fig. 19

*Ophiacantha metallacta* H. L. Clark, 1915: 202.

MATERIAL STUDIED. MCZ: *Blake* Stn 320 off S. Carolina 463 m PARATYPE.

The disk is round, diameter up to 7 mm, covered by multipointed spinelets which have a very wide crown, approximately round in the top view with many irregular points, often 10 or more. The radial shields are inconspicuous. The ventral interradial areas are covered by similar spinelets to the dorsal side but they become less dense nearer the proximal part of the disk.

The jaws appear as broad as long. There is one pointed apical papilla flanked on each side by 3 oral papillae, the distalmost of which is leaf shaped with a rounded outer edge. The adoral shields are large, wing-like, and do not separate the oral shield from the first lateral arm plate. The oral shield is rhombic almost pentagonal, the centre of the shield may be slightly depressed.

The arms are slightly noded. The dorsal arm plates are triangular and separated although proximally they may be nearly contiguous. The ventral arm plates are nearly pentagonal with a rounded distal edge. They are contiguous proximally. The distal portion of the plate has transverse striations which are also present on the lateral arm plates. The tentacle pores are armed with one flat leaf shaped tentacle scale. There are 7 slightly rugose arm spines, often with larger points along the shaft of the spine. The spines on proximal segments nearly meet midradially forming a fan.

REMARKS. *O. metallacta* bears a close resemblance to *O. notata* but differs in the shape of the oral and adoral shield (see Table 1).

DISTRIBUTION. This species has been recorded from the western Atlantic where it has been found from the West Indies as far north as South Carolina 295–763 m.

*Ophiacantha notata* Koehler, 1906

Fig. 19

*Ophiacantha notata* Koehler, 1906: 23; 1907: 284.

MATERIAL STUDIED. MNHN: *Travailleur & Talisman* 1881 Stn 39 44°5'N: 9°20'40"W 1226 m HOLOTYPE.

The disk is round and densely covered by spinelets with a multipointed crown; disk diameter is 8 mm. The tips of the radial shields are visible and the extent of the shields can be seen beneath the disk scales. The ventral interradial areas are also covered with spinelets.

The jaws appear slightly angular and pointed. There is one pointed, slightly angular, apical papilla flanked on each side by 3 to 4 irregularly arranged long pointed oral papillae, some of which are slightly flattened. The adoral shields are extremely wing-like with the lateral edges acutely pointed. They lie proximal to the oral shield and not separating it from the first lateral arm plate. The oral shield is distinctly pentagonal, with an obtuse proximal angle and a convex distal edge. There may be a slight depression in the plate.

The arms are noded. The dorsal arm plates are fan to bell shaped and separated. The ventral arm plates are slightly pentagonal with a nearly straight proximal edge and convex distal edge. The distal segment is strongly striated. Striations also occur on the lateral arm plates. The tentacle pores are small, each armed with one large flap-like tentacle scale, which is pointed on proximal pores but becomes rugose on distal ones. There are 7 to 8 arm spines, the dorsalmost of which are finely rugose while the ventral are highly rugose and are slightly curved and club shaped. The arm spines do not form a fan on the proximal joints.

REMARKS. *O. notata* appears to be similar to *O. parvita*, *O. lineata*, and *O. metallacta*, see Table 1. *O. notata* can be distinguished by its angular wing-like adoral shields and the shape of the oral shield.

DISTRIBUTION. This species has only been recorded from the Bay of Biscay at a depth of 1226 m.



*Ophiacantha parvita* Koehler, 1906

Fig. 19

*Ophiacantha parvita* Koehler, 1906: 25; 1907: 286.

MATERIAL STUDIED. MNHN: *Traivailleur* & *Talisman* 30 Juillet 1883 Stn 114 16°51'N: 27°30'W 633–598 m 1 specimen.

The disk is round, up to 9 mm in diameter, covered by spinelets with a narrow crown of up to 8 points. The radial shields are visible in some specimens but in others they are partially or totally obscured by the spinelets. The ventral interradial areas are also covered with spinelets.

The jaws appear slightly longer than broad. There is one pointed apical papilla flanked on each side by 3 oral papillae, the distalmost of which is long with its free and widened and squared off. The adoral shields are short slightly larger than wide with the proximal edge at nearly right angles to the jaw; they do not separate the oral shields from the first lateral arm plate. The oral shield is very distinctive with a rounded proximal edge and the distal edge produced resembling a deformed light bulb in profile.

The arms appear to be wide and slightly flattened. The dorsal arm plates are triangular and almost contiguous proximally. The lateral arm plates are wide and the area where the spines articulate is not raised up as much as in species like *O. bidentata* but is flatter. The ventral arm plates are short almost as wide as long pentagonal with the distal edge curved and are contiguous or nearly contiguous proximally. The lateral and ventral arm plates have distinctive transverse ridges most noticeable in dry specimens. The tentacle scale is flat and scale-like, rounded not pointed. There are up to 10 short only slightly rugose arm spines.

REMARKS. *O. parvita* can be distinguished from the other species which have striations on the ventral and lateral arm plates by the shape of the adoral and oral shield and the arm (see Table 1).

DISTRIBUTION. *O. parvita* has been recorded once—from the Cape Verde Island, 633–598 m. It is included in the present study because it may possibly occur in deeper water elsewhere in the North Atlantic.

*Ophiacantha rosea* Lyman 1878

Fig. 18

*Ophiacantha rosea* Lyman, 1878: 139; 1882: 184; Verrill, 1899a: 42; 1899b: 331; Koehler, 1897a: 81–82; Mortensen, 1927: 189–190.

*Ophioprium rosea*: Baker & Devaney, 1981: 173–174.

MATERIAL STUDIED. BMNH: HMS *Challenger* Stn 308 50°10'S: 74°42'W 320 m HOLOTYPE & 1 PARATYPE.

The disk is round, disk diameter up to 15.5 mm, covered by long spinelets. Some of these longer spinelets end in only a few points, others are shorter more rugose with a multipointed crown. In the holotype the radial shields are visible as a thin area devoid of spinelets, this is not so distinct in the paratype. The ventral interradial area is covered by similar spinelets to the dorsal side.

The jaw appears short and wide. There are up to 3 broad pointed apical papilla flanked on either side by 3 broad flap-like oral papillae. Several pointed supernumerary papillae are present on the edge of the jaw and often on the proximal edge of the adoral shields. The adoral shields are just longer than broad and positioned almost totally proximal to the oral shield. The oral shield is a rounded rectangular shape slightly longer than broad.

The arms are quite broad, not particularly noded. The dorsal arm plates are fan shaped, contiguous proximal, but well separated distally. The ventral arm plates are roughly pentagonal with a convex almost angular distal edge, and are separated. The tentacle pores are quite large often the proximal ones are built up. On the first tentacle pore of the arm there 2 often 3 large broad flap-like tentacle scales, subsequent pores have one broad flap-like scale with sometimes a smaller pointed more spine-like scale. There are 10–11 arm spines on the proximal joints 7–8 on distal ones. The second dorsalmost arm spine is the longest and maybe nearly 3 arm segments long. The arm spines are finely rugose. They do not form a fan on proximal segment.

REMARKS. *O. rosea* can be distinguished from the other species of *Ophiacantha* by the following characters: the arrangement of the papillae on the jaw the shape and arrangement of the adoral and oral shields; the large tentacle scales and their number on the proximal pores. Baker & Devaney (1981) consider *O. rosea* to be a species of *Ophioprium* because the oral papillae are of two sizes which are located on different parts of the jaw and the tentacle pores are large armed

with large tentacle scales. However there are several reasons which suggest that *O. rosea* should be retained in *Ophiacantha*: firstly in all specimens examined the jaws are short, broader than long not longer than broad as in *Ophioprium*. Secondly, although larger specimens of *O. rosea* examined often have many smaller thinner supernumerary papillae such papillae are not distributed in a similar way to other species of *Ophioprium*. They appear to be quite randomly arranged on the distal portion of the jaw although sometimes they appear to cluster in the region of the second oral tentacle pore. In *Ophioprium cervicornis* the two types of papillae are distributed in a regular way; the smaller papillae are situated on the proximal part of the jaw and can be regarded as the oral papillae. Distal to them there are several longer more spine-like papillae usually associated with the second oral tentacle pore; these papillae can be regarded as tentacle scales. As discussed under the subfamily Ophiotominae this is a common arrangement amongst its genera. Smaller specimens of *Ophiacantha rosea* have an arrangement of 3–4 oral papillae much like other species of *Ophiacantha*. Lastly in *Ophioprium cervicornis*, *O. permixtum* the pores are open with small spine-like tentacle scales or none at all. In *O. rosea* the tentacle pores are relatively large but are armed with a large tentacle scale.

**DISTRIBUTION.** *O. rosea* has a wide distribution being found in the Pacific off Japan, southern Chile; South Africa, Marion Island; and in the Atlantic from the Bay of Biscay. In the Atlantic it has a bathymetric distribution of 1410–1700 m.

### *Ophiacantha densa* Farran, 1913

Fig. 20

*Ophiacantha densa* Farran, 1913: 40; Cherbonnier, 1970: 1272.

**MATERIAL STUDIED.** **BMNH:** Irish Fisheries *Helga* Stn SR 504 50°42'N: 11°18'W 1128–1310 m **HOLOTYPE & PARATYPE.**

**COB:** BIOGAS Stn HZ: CM01 1100 m 1 specimen.

The disk is round, diameter up to 5–6 mm covered with a dense coating of spinelets, which are rod-like with bifid tips and in some specimens may be covered with skin. The radial shields are inconspicuous. The ventral interradial areas are also covered with spinelets like those of the dorsal surface.

The jaws appear to be as broad as long. There is one pointed apical papilla flanked on either side by 3 conical, pointed oral papillae. The adoral shields are larger about twice as long as broad, slightly curved, and do not separate the oral shield from the first lateral arm plate. The oral shield is small rhombic to triangular in shape. The oral and adoral shields, and to some extent the lateral arm plates and the ventral arm plates, have very conspicuous glassy tubercles embedded in the plates.

The arms are distinctly noded. The dorsal arm plates are bell shaped or triangular with a convex distal edge and are separated. The ventral arm plates are pentagonal often with a rounded distal edge, and are separated. Each tentacle pore has one small pointed tentacle scale. There are 4–5 smooth arm spines, the proximal ones well separated midradially, not forming a fan.

**REMARKS.** *O. densa* has an affinity with *O. smitti* Ljungman; both have a similar arrangement of the oral frame and the adoral and oral shields have glassy tubercles. *O. densa* has fewer arm spines, 4–5 as opposed to 7–8, the oral frame is not raised away from the ventral portion disk, there are no trifid spinelets amongst the rods of the disk as there commonly are in *O. smitti* and the arm spines do not form a fan on proximal arm segments.

**DISTRIBUTION.** *O. densa* has been recorded from the eastern Atlantic off SW. Ireland and in the Bay of Biscay; 300–1324 m.

### *Ophiacantha smitti* Ljungman, 1872

Fig. 20

*Ophiacantha smitti* Ljungman, 1872: 615; Lyman, 1882: 179; Koehler, 1926: 25; Nobre, 1931: 81; Cherbonnier & Sibuet, 1972: 76.

*Ophiacantha segesta* Lyman, 1878: 141–142.



**MATERIAL STUDIED.** **BMNH:** HMS *Challenger* Stn 56 off Bermuda 1996 m HOLOTYPE of *O. segesta*.  
**COB:** BIOGAS Stn HZ: DS04 1100 m 4 specimens; CM01 13 specimens; CV21 994 m 2 specimens. BIO-  
 GAS Stn 1: CV20 2282 m 46 specimens.  
**IOS:** *Discovery* Investigations: Stn 8967 31°25'9"N: 10°25'9"W 2 specimens.

The disk is round, diameter up to 8 mm, sometimes with a domed appearance due to the arched radial shields but this may be an artifact of preservation. The disk is covered by a dense coating of simple rods and trifid and bifid spinelets which are sometimes reduced resembling small granules, the proportions of each varies some specimens having nearly all rods. Generally the spinelets are situated periferally extending onto the ventral interradial areas whereas the rods are found in the middle of the disk. The rods and spinelets may be covered with a coating of skin.

The jaws appear to be as broad as long. The oral frame has the appearance of standing out from the disk. There is one large pointed apical papilla flanked on each side by 3 rounded spinelike oral papillae. The adoral shields are large, swollen, slightly curved and not separating the oral shield from the first lateral arm plate. The oral shield is small and triangular. The adorals and oral shields, ventral and lateral arm plates have conspicuous glassy tubercles embedded in the matrix of the plate.

The arms are distinctly noded. The dorsal arm plates are triangular or slightly bell shaped with a convex distal edge and are separated. The ventral arm plates are pentagonal and in some specimens the distal edge may be indented. The tentacle scale is small and pointed. There are 7–8 smooth arm spines, the first 3–4 dorsal spines are the longest and on proximal segments are smoother and thinner than the ventral ones. On the proximal arm segment the arm spines almost meet midventrally forming a fan.

**REMARKS.** *O. smitti* is a variable species with the covering of the disk varying from being densely covered with rods and spinelets to being quite open. Also the proportion of rods to spinelets varies to the exclusion of spinelets which would lead to confusion with *O. densa* were it not for the different number of arm spines, the proximal spines forming a fan and the raised oral frame.

*O. segesta* Lyman from off Bermuda was thought to differ from *O. smitti* in having longer, thinner spinelets and rods sparsely distributed over the surface of the disk and the arm spines, particularly the ventral ones, were more rugose. However, a large sample of *O. smitti* shows so much variation in these characters that the type material of *O. segesta* cannot be considered other than conspecific with *O. densa*.

**DISTRIBUTION.** This species has been recorded from both sides of the North Atlantic: in the east from the Bay of Biscay south to off North Africa in depths of 994–2282 m, and in the west off Bermuda 1996 m.

### *Ophiacantha abyssicola* G. O. Sars, 1871

Fig. 20

*Ophiacantha abyssicola* G. O. Sars, 1871: 8; Bell, 1892: 128; Nordgaard, 1893: 5; Grieg, 1893: 24; 1895: 10; Koehler, 1895: 463; 1896a: 79; 1896b: 213; 1898: 55; Grieg, 1903: 31; Kemp, 1905: 183; 195: Koehler, 1906: 42; 1907: 287; 1909: 182; Farran, 1913: 38; Mortensen, 1913: 356; Grieg, 1921: 73; Koehler, 1924: 247; Mortensen, 1925: 180; 1927: 194; Grieg, 1932: 37; Mortensen, 1933a: 23–24; Djakanov, 1935: 86; 1954: 38; Madsen, 1970: 15; Gage *et al.*, 1983: 289.

*Ophiacantha millespina* Verrill, 1879: 203; 1899b: 324; H. L. Clark, 1915: 203.

**MATERIAL STUDIED.** **BMNH:** *Porcupine* Stn 74 W. of Shetlands 365 m 9 specimens; *Knight Errant* NW of Rona 927 m 3 specimens; Norman Collection Rödburg, Norway 2 specimens.

**COB:** BIOGAS Stn HZ: DS04 1100 m 4 specimens; DS05 2210 m 1 specimen; DS07 2170 m 1 specimen.

**IOS:** *Discovery* Investigations: Stn 7844 23° 43'27"N: 16°56'66"W 485–479 m 5 specimens; Stn 48°48'N: 11°49'7"W 955 m.

**SMBA:** RRS *Challenger II*: Stn: ES 23 56°37'N: 09°10'W 704 m 4 specimens; Stn ES 115 56°29'N: 10°22'W 1000 m 4 specimens.

The disk is round, up to 8 mm in diameter, covered with glassy spinelets, which are basically elongated trifids often elaborated with secondary points, sometimes one of the points may be greatly enlarged resembling a rod. The plates of the interradial region are usually large and conspicuous.

The jaws appear to be as broad as long. There is one pointed apical papilla flanked on either side by 3–4 oral papillae; the free end of the distalmost one may be widened. The adoral shields are large, about twice as long as broad, and do not separate the oral shield from the first lateral arm plate. The oral shield varies from

being roughly pentagonal to distinctly arrow shaped. There is a distinct groove or depression in the distal part of the plate.

The arms are noded. The dorsal arm plates vary from fan shaped to bell shaped, and are separated. The ventral arm plates are distinctly wider than long, pentagonal in shape and separated. Each tentacle pore is armed with one pointed tentacle scale. There are 6–8 slightly rugose arm spines, the dorsalmost arm spines are the longest up to 2 arm segments long, the ventral most are usually the most rugose. On distal segments of the arm the ventralmost arm spines may be flattened and have a comblike structure along one edge. The spines on the proximal joints may join midradially forming a fan.

**REMARKS.** *O. abyssicola* is easily recognised by the arrow shaped oral shield, the very wide and separated ventral arm plates and the elaborated trifold disk spinelets. *O. abyssicola* closely resembles the holotype and only known specimen of *O. granulifera* Verrill: both have similarly shaped oral shields and ventral arm plates. Indeed certain specimens of *O. abyssicola* studied showed intermediate characters between the two. However, *O. abyssicola* differs from *O. granulifera* by the following characters: the arm spines only form a fan on the first free arm joint while in *O. granulifera* the fans extend along at least half the arm; the spinelets of the disk differ, those of *O. abyssicola* are trifold and glassy while those of *O. granulifera* are low and resemble granules; *O. abyssicola* has a rounded disk whereas *O. granulifera*'s disk is indented interradially, although this could be an artifact of preservation.

Several features of *O. abyssicola* and *O. granulifera* distinguish them from most species of *Ophiacantha*: the high often indented disk, the arm spines of *O. granulifera* forming a fan on most proximal arm segments, large conspicuous disk plates and the very wide ventral arm plates are all reminiscent of the Ophioplithacinae. But most members of that subfamily have large conspicuous radial shields and a slightly different arrangement of the jaw.

**DISTRIBUTION.** This is a predominantly bathyal species recorded from both sides of the North Atlantic: in the west from Cape Hatteras north to southern Greenland of depths of 561–1048 m; in the east from SE. Iceland, northern Norway (the Lofoten Islands) south to the Canary Islands at depths of 260–2300 m.

### *Ophiacantha granulifera* Verrill, 1885a

Fig. 20

*Ophiacantha granulifera* Verrill, 1885a: 153; 1899a: 38; 1899b: 326; Koehler, 1914: 86–87; Wheateaves, 1901: 61.

**MATERIAL STUDIED.** MCZ: Off Georges Bank 181 m HOLOTYPE.

The disk is high and indented interradially, disk diameter 9 mm. It is covered by low multipointed granules. The radial shields are inconspicuous amongst the plates of the disk. The ventral interradial area is devoid (in this specimen) of any granules and the plates of this area are large and conspicuous.

The jaw appears to be wider than long. There is one large, broad, pointed apical papilla flanked on either side by 3–4 large slightly blunt oral papillae. The adoral shields are about twice as broad as long and are wing-like separating the oral shield from the first lateral arm plate. The oral shield is arrow shaped with the distal projection slightly depressed.

The arms are noded flattened ventrally. The dorsal arm plates are triangular and separated. The ventral arm plates are much wider than long with an obtuse proximal angle and a straight distal edge rounded at the corners and indented midradially. There are two flattened rounded tentacle scales on the most proximal arm segment, subsequent pores have only one and distally the tentacle scale becoming quite small. There are 9 finely rugose arm spines. The longest is the second dorsalmost spine which is up to two arm segments in length. Ventral arm spines may be slightly flattened and in some the arm spine may be curved. The arm spines form a fan on the proximal arm segments. The matrix of the arm joints, the subsequent plates ventral plates and jaw plates appears coarse.

**REMARKS.** See under *O. abyssicola*.

**DISTRIBUTION.** This species has only been recorded from the western Atlantic off the Georges Bank, off Cape cod 184 m.



*Ophiacantha spinosella* Mortensen, 1933a

Fig. 21

*Ophiacantha spinosella* Mortensen, 1933a: 29–30.

MATERIAL STUDIED. ZMC: Thor Stn 57 63°21'N: 16°27'W 500–560 m HOLOTYPE.

The disk is round, diameter of holotype 2 mm, covered by imbricating scales many of which carry a rugose rodlike spinelet. The radial shields are not visible. The ventral interradial area is covered by scales like those of the dorsal side but with fewer shorter spinelets.

The jaws appear slightly longer than broad. There is a pointed slightly rugose apical papilla flanked on either side by 3–4 pointed oral papillae which form a continuous series with 2–3 tentacle scales of the second oral tentacle pore. The adoral shields are long and narrow, separating the oral shield from the first lateral arm plate. The oral shield is rounded, triangular, sometimes with a slight distal lobe.

The arms are noded. The dorsal arm plates are fan shaped and separated. The ventral arm plates are pentagonal and separated. The tentacle pores are relatively large with two flat pointed tentacle scales on the first arm pore and one on subsequent pores. There are 4–5 rugose arm spines, the dorsalmost one is longest, up to 2 segments long. They do not form a fan on the proximal joints.

REMARKS. The arrangement of the oral papillae and tentacle scales of the second oral tentacle scales are reminiscent of the subfamily Ophiotominae. These characters coupled with the relatively large tentacle pores suggest that this species is not an *Ophiacantha* but perhaps a young stage of a species of the Ophiotominae. This must remain uncertain until more specimens are found.

DISTRIBUTION. *O. spinosella* has been recorded once, off Iceland at a depth of 500–560 m.

*Ophiotreta valenciennesi rufescens* Koehler, 1896c

Fig. 21

*Ophiacantha rufescens* Koehler, 1896c: 249–250.*Ophiacantha valenciennesi*: Koehler, 1909: 188–189.*Ophiotreta valenciennesi*: Koehler, 1914: 102.*Ophiacantha valenciennesi* var *rufescens*: Mortensen, 1933a: 36–37; Cherbonnier, 1962: 7–9.

MATERIAL STUDIED. MNHN: *Princesse Alice* Stn 584 38°31'N: 29°9'3"W 845 m 10 specimens; *Travailleur* et *Talisman* No. 70 1883 25°39'N: 18°18'W 698 m 10 specimens.

IOS: *Discovery* Investigations: Stn 8966 31°21'N: 10°41'5"W–31°22'N: 10°39'2"W 686–742 m 10 specimens.

The disk is round, diameter up to 15 mm, densely covered with low granules or spinelets which are very rugose and do not form a crown. Only the tips of the radial shields are visible. The ventral interradial areas are also covered by spinelets although the extent of covering varies; in some specimens only the distal portion has spinelets, in others it is totally covered.

The jaws appear to be elongated, distinctly longer than broad. In some specimens the apical papilla may not be distinct while in others there are 1 or 2 large, pointed papillae; these are flanked by up to 6 flat, pointed or sometimes scale-like oral papillae. The distalmost one is larger than the others and is scale-like. The adoral shields are slightly wing-like, not or just separating the oral shield from the first lateral arm plate. The oral shields are large and arrow shaped but in some specimens the shield may be more rounded.

The arms are only slightly noded. The dorsal arm plates are bell shaped sometimes with a distinct lobe on the distal edge, and contiguous. The ventral arm plates are wider than long, pentagonal with an obtuse proximal angle and a slightly convex distal edge. The tentacle pores are relatively large armed with 2 flat scale-like tentacle scales, and occasionally the first arm pore may have 3, the third may lie hidden beneath the other two. There are 7–8 distinctly flattened, finely rugose arm spines, with the tips squared off. The arm spines do not form a fan on the proximal joints.

REMARKS. *O. valenciennesi rufescens* differs from *O. valenciennesi* Lyman (Challenger Stn 192 off Kei Is 236 m) in the following respects: the disk spinelets are not as rugose as those of *O. valenciennesi* and the adoral shields do not or only just separate the oral shield from the first lateral arm plate, those of *O. valenciennesi* are more wing-like and extend to the genital slits. However, these are minor differences insufficient to warrant more than an infraspecific distinction, supporting Mortensen's (1933) evaluation.

The complex jaw arrangement and the relatively large tentacle pores of *O. valenciennesi* suggest an affinity with the subfamily Ophiotominae particularly with the genus *Ophiopristis*.

**DISTRIBUTION.** This species has been recorded from off Madeira south to Angola from 640–1440 m.

*Ophiacanthella troscheli* (Lyman, 1878)

Fig. 21

*Ophiacantha troscheli* Lyman, 1878: 142; 1882: 190.

*Ophiacanthella troscheli*: Verrill, 1899a: 39; Matsumoto, 1915: 62.

**MATERIAL STUDIED.** BMNH: HMS *Challenger* Stn 33 Bermuda 796 m HOLOTYPE.

The disk is pentagonal, diameter up to 6 mm, covered by very small fine scales; the holotype has a slightly transparent appearance. The scales are armed with low granules and simple spines. The radial shields are visible, distinctly longer than wide the distal portion of the shield bulges and touches or overlaps the opposite shield, the distal ends are separated. The ventral interradiation areas are also covered by low granules.

The jaw appears as wide as long. There is usually one pointed apical papilla sometimes two or three flanked on each side by 3–4 pointed oral papillae. Distal to the oral papillae the second oral tentacle pore is particularly prominent. The adoral shields are large wing-like and separate the oral shield from the first lateral arm plate. The oral shield is oblong to rhombic.

The arms are slightly noded. The dorsal arm plates are fan shaped and contiguous on proximal segments. The ventral arm plates are pentagonal and separated from one another. The tentacle pores are not enclosed by the lateral arm plates but are open. The tentacle scale is small and pointed. There are 5 finely rugose and slightly flattened arm spines, of which the dorsalmost is the largest extending about 2 arm segments in length. The arm spines do not form a fan across the midradial on proximal arm segments.

**REMARKS.** *O. troscheli* is characterised by the contiguous radial shields and the two kinds of disk spinelets—low rugose granules and spines.

**DISTRIBUTION.** *O. troscheli* has only been recorded from the western Atlantic; from Bermuda 796 m.

*Ophiolebes pachyphylax* H. L. Clark, 1915

Fig. 22

*Ophiacantha anomala*?: Lyman, 1883: 260.

*Ophiolebes pachyphylax* H. L. Clark, 1915: 194.

**MATERIAL STUDIED.** MCZ: Blake Stn 306 41°32'50"N: 65°55'W 943 m HOLOTYPE.

The disk is round to sub pentagonal, diameter up to 8 mm; covered with small umbricating scales, in the dried holotype there is no indication of a covering of skin, many carrying a low spinelet with a multipointed crown. The radial shields are bar shaped separated, often covered over by the disk scales; and extended slightly less than half the disk radius. The ventral interradiation areas are covered by scales and spinelets similar to those of the dorsal side.

The jaws are as wide as long. There is one long, finely rugose, club-like apical papilla flanked on each side by 4 oral papillae similar in shape and size to the apical papilla. In addition there may be one or two smaller papillae lying slightly below the oral papillae series between the first and second or the second and third oral papillae. The adoral shields are slightly curved large and occupying a large portion of the jaw proximal to the oral shield. The oral shield is rhombic often with the distal edge slightly produced.

The arms are noded. The dorsal arm plates are scallop shaped and separated from one another. The proximal ventral arm plates are approximately trapezoidal with a wide convex distal edge, they are contiguous with one another at least proximally. The distal ventral arm plates are more pentagonal with an obtuse proximal angle and a wide convex distal edge. The tentacle pores are small armed with a small, rugose, pointed tentacle scale. There are 7 arm spines proximally. The dorsal spines are long, pointed and finely rugose while the ventral ones are shorter, club shaped and often highly rugose with large secondary points on the shaft of the arm spine. The second dorsalmost spine is the longest, nearly 2 arm segments long, proximal arm spines do not form a fan.

REMARKS. *O. pachyphylax* disagrees in two characters with the descriptions of other species of *Ophiolebes*, including the type species *O. scor-teus* Lyman, 1878. Firstly, the arm spines are long, up to 2 segments long while in the other species they tend to equal only one arm segment and secondly the skin of the disk is not thickened obscuring the plates beneath, although this may be an artefact due to the dried condition of the holotype there is usually some indication of a skin covering even in dried specimens. Other species of *Ophiolebes* species have a thickened skin covering the disk and to a certain extent the arm spines.

*O. pachyphylax* differs from *O. bucata* in having 7 long dorsal arm spines as opposed to 5 short ones in *O. bucata*, and in the disk armament.

Lyman (1883) was unsure of the identity of this species and assigned it to *Ophiacantha* thinking that it might be a juvenile *O. anomala*. H. L. Clark (1915) compiling his catalogue of specimens in the MCZ recognised it as a new species of *Ophiolebes*.

DISTRIBUTION. *O. pachyphylax* has only been recorded from off Nantucket 943 m.

### *Ophiolebes bucata* Koehler, 1921

Fig. 22

*Ophiolebes bucata* Koehler, 1921: 5–8.

MATERIAL STUDIED. MOM: *Princesse Alice* Stn 3113 1911 32°34'45"N: 17°05'30"W 1700 m HOLOTYPE.

COB: BIOGAS Stn 1 CV23 2034 m 1 specimen.

The disk is subpentagonal, slightly indented interradi-ally, diameter up to 4.5 mm; densely covered by small rugose granules. The radial shields are also covered with rugose granules but it is possible to distinguish their position on the disk. The ventral interradi- al areas are also covered by low granules.

The jaws appear to be as wide as long. There is one pointed apical papilla flanked on either side by 3–4 blunter oral papillae. There is a small spine-like papilla lying within the mouth slit which is probably the first oral tentacle scale. The adoral shields are large and are restricted to the proximal sides of the oral shield, not separating it from the first lateral arm plate. The oral shield is rhombic, often with a slight distal projection. The adoral and oral shields and the arm plates are textured with glassy granules embedded in the matrix of the plate.

The arms are not noded. They are long and are capable of coiling vertically. The dorsal arm plates are fan shaped and not contiguous. The ventral arm plates are pentagonal with an acute proximal angle, a slightly indented distal edge, and separated from one another. The tentacle pores are quite small each armed with a very small tentacle scale. There are 5 short arm spines, the longest is scarcely equal in length to one segment. Ventral arm spines have a distally directed, hooked tip or at least conspicuous secondary points at the tip. This feature becomes more conspicuous on distal arm segments.

REMARKS. *O. bucata* is distinguished from *O. pachyphylax* under the REMARKS section of that species.

DISTRIBUTION. This species has been recorded from the eastern Atlantic from the Bay of Biscay and off Madeira 1300–2034 m.

### *Ophiolebes retecta* (Koehler, 1895)

Fig. 22

*Ophioscolex retectus* Koehler, 1895: 462; 1896a: 78–79.

*Ophiolebes retecta* Mortensen, 1927: 183, 185.

MATERIAL STUDIED. MNHN: *Caudan* 1895 45°57'N: 6°21'W 1410 HOLOTYPE.

COB: BIOGAS Stn 1: CV20 2282 m 1 specimen.

The disk is pentagonal up to 7 mm; covered with thin skin covering a coating of imbricating scales many carrying a low granule. The radial shields are visible through the skin of some preserved specimens and are long bar shaped widely separated from one another. The ventral interradi- al areas are skin covered with a coating of granules.

The jaws are as broad as long. There is one long pointed apical papilla with 2–3 oral papillae on each side of the jaw. The oral papillae are small and pointed, irregularly arranged either along the edge of the jaw or slightly more superficial. The jaw, oral and adoral shields and the underside of the arms are covered with



thick skin, which in wet specimens almost obscures the outlines of the plates beneath. The adoral shields are short, slightly curved and situated proximal to the oral shield, not separating it from the first lateral arm plate. The oral shield is rhombic but often with an obtuse proximal angle and a convex distal edge.

The arms are capable of coiling vertically. The dorsal arm plates are divided transversely into two; the proximal part is small rounded or rectangular and the outer one is rounded trapezoidal with a convex distal edge. The double plates of consecutive segments, are not contiguous with the next pair. The ventral arm plates are approximately pentagonal with an obtuse proximal indented in the middle and are separated from one another. The tentacle pores are small and are absent on arm segments beyond the second or third segment. Tentacle scales are either absent or inconspicuous. There are up to 8 rugose arm spines which are invested with thickened skin.

**REMARKS.** In the characters of the divided dorsal arm plates and the oral papillae *O. resecta* bears a closer resemblance to *Ophiochondrus armatus* than to any of the other species of *Ophiolebes*. The only characters which appears to separate them are the scaling of the disk, which is formed of imbricating plates in *O. resecta* but non-imbricating plates in *Ophiochondrus*, and the covering of thick skin over the jaws and ventral part of the arm in *O. resecta* which is absent in *Ophiochondrus*. It is possible that *O. resecta* is referable to *Ophiochondrus* but inadequate material prevents a satisfactory assessment of this problem. In addition Mortensen (1927) has called attention to the fact that *Ophiochondrus armatus* may not be congeneric with *Ophiochondrus convolutus* Lyman, 1869, the type species. It seems best at present to leave *Ophiolebes resecta* in *Ophiolebes* until *Ophiochondrus* and its allies can be properly revised.

The above remarks also apply to the Japanese species *Ophiolebes tuberosa* Matsumoto, 1917 which closely resembles *O. resecta*. It too has divided dorsal arm plates and its inclusion in *Ophiolebes* is also suspect.

**DISTRIBUTION.** *Ophiolebes resecta* has only been recorded from the Bay of Biscay at depths of 1410–2282 m.

#### OPHIOTOMINAE Subfamily nov.

**DIAGNOSIS.** A subfamily of the Ophiacanthidae with a sack-like disk covered with thickened skin or thin scales which often carry spinelets or granules; radial shields variable in shape, either rib-like with only the distal ends not covered by scales or short with most of the plate visible; the jaws distinctly longer than broad; one or sometimes as many as three large blunt apical papillae flanked on each side by three to many oral papillae; in most genera the second oral tentacle pore arising superficially or nearly so and the associated tentacle scales often forming a continuous series with the oral papillae; the oral tentacle scales often spine-like and larger than the oral papillae, except in *Ophiolimna* where the second oral tentacle pore is obscured by a large opercular distal oral papillae; nearly all genera with well developed elongated adoral shields and a large oral shield; the tentacle pores of the arm mostly large and often with small spine-like tentacle scales although some genera with smaller pores armed with well developed tentacle scales; the arm spines relatively short usually only slightly longer than one arm segment.

**TYPE GENUS** *Ophiotoma* Lyman, 1883 with type species *O. coriacea* Lyman, 1883.

**REMARKS.** Genera included in this subfamily are *Amphilimna* Verrill, 1899a, *Ophiocymbium* Lyman, 1880, *Ophiodaces* Koehler, 1922b; *Ophidelos* Koehler, 1930; *Ophiolimna* Verrill, 1899a; *Ophiologimus* H. L. Clark, 1911; *Ophiomedeia* Koehler, 1906; *Ophiophiura* H. L. Clark, 1911; *Ophiopristis* Verrill, 1899a; *Ophioprium* Verrill, 1899a; *Ophiosparte* Koehler, 1922b; *Ophiotoma* Lyman, 1883; *Ophiotrema* Koehler, 1896c.

H. L. Clark (1915) considered *Ophiopristis* to be congeneric with *Ophiacantha* but as outlined on p. 53 I believe that *Ophiopristis* is not only a valid genus but also referable to a separate subfamily.

The most important features of this subfamily are found in the mouth parts and the tentacle pores.

Commonly the second oral tentacle pore is quite superficial situated adjacent to the proximal edge of the adoral shield. The various arrangements of the tentacle scales associated with this pore provide useful generic characters. They may form a continuous series with the oral papillae as in the genus *Ophiopristis*. This may also be true for *Ophidelos* and *Ophiologimus* judging from original figures and descriptions.

The tentacle scales may be distinct from the oral papillae being either separated by a gap or placed at a higher level as viewed from the ventral side as in the genera *Ophiotoma* and *Ophioblenna*. In these two genera the tentacle pores on the arm are open and do not usually have tentacle scales. The tentacle scales may also be distinguished by their size or shape as well as position, as in the genera *Ophiotrema*, *Ophioprium*, *Ophiophiura*, *Ophiosparte* and *Ophiodaces*. Here the oral tentacle scales tend to be larger than the oral papillae as well as being separated above them. There is however a gradation between these five genera and genera like *Ophiotoma*. For instance, *Ophiotoma affinis* Koehler, 1921, unlike *Ophiotoma coriacea* has an arrangement of oral papillae and tentacle scales similar to *Ophiotrema alberti* Koehler, 1896c. The tentacle pores of this latter group are open and often armed with small spine-like tentacle scales except in *Ophiosparte* which has open-tentacle pores but a well developed tentacle scale which forms a continuous series with the arm spines.

In *Ophiomedeia* and *Ophiocymbium* the second oral tentacle pore becomes increasingly superficial and the oral tentacle scales can easily be distinguished. The tentacle pores on the arms of these two genera are open and large with only small spine-like tentacle scales being present if at all.

The exception to the kinds of oral arrangements mentioned is *Ophiolimna*. Here the oral pore although quite superficial is hidden by an opercular papillae, the distalmost in the oral series. Whether this is a true oral papillae or a modified tentacle scale is uncertain. *Ophiolimna* is included in this subfamily because it has elongated jaws, a similar arrangement of the oral and adoral shields to the other genera in the Ophiotominae. The tentacle pores of the arms are not as open as in other members of this subfamily and are armed with one large tentacle scale, resembling the arrangement of *Ophiopristsis*, and may be intermediate between the Ophiotominae and Ophiacanthinae but pending further study should remain in the Ophiotominae.

There appears to be some confusion concerning the genera *Ophioprium* and *Ophiopristsis*. H. L. Clark (1915) did not consider *Ophiopristsis* to be a distinct genus and transferred the type species *O. hirsuta* to *Ophiacantha* the remaining species *O. cervicornis*, *O. permixta* and *O. axiologia* together with a new species *O. imperfectum* he transferred to a new genus *Ophioprium* with the type species *O. cervicornis*. *Ophioprium* was defined as follows: hidden radial shields; large tentacle pores armed by two or more tentacle scales one attached to the lateral arm plate the other to the ventral arm plate; numerous oral papillae forming a continuous series with long slender spinelets which are associated with the second oral tentacle pore. Clark added that he was uncertain that *O. axiologia* and *O. imperfectum* did belong in *Ophioprium*.

Baker (1979) added two more species *O. larissae* and *O. kalalae* and Baker & Devaney (1981) proposed to transfer *Ophiacantha rosea* Lyman to *Ophioprium* (see under *Ophiacantha rosea*).

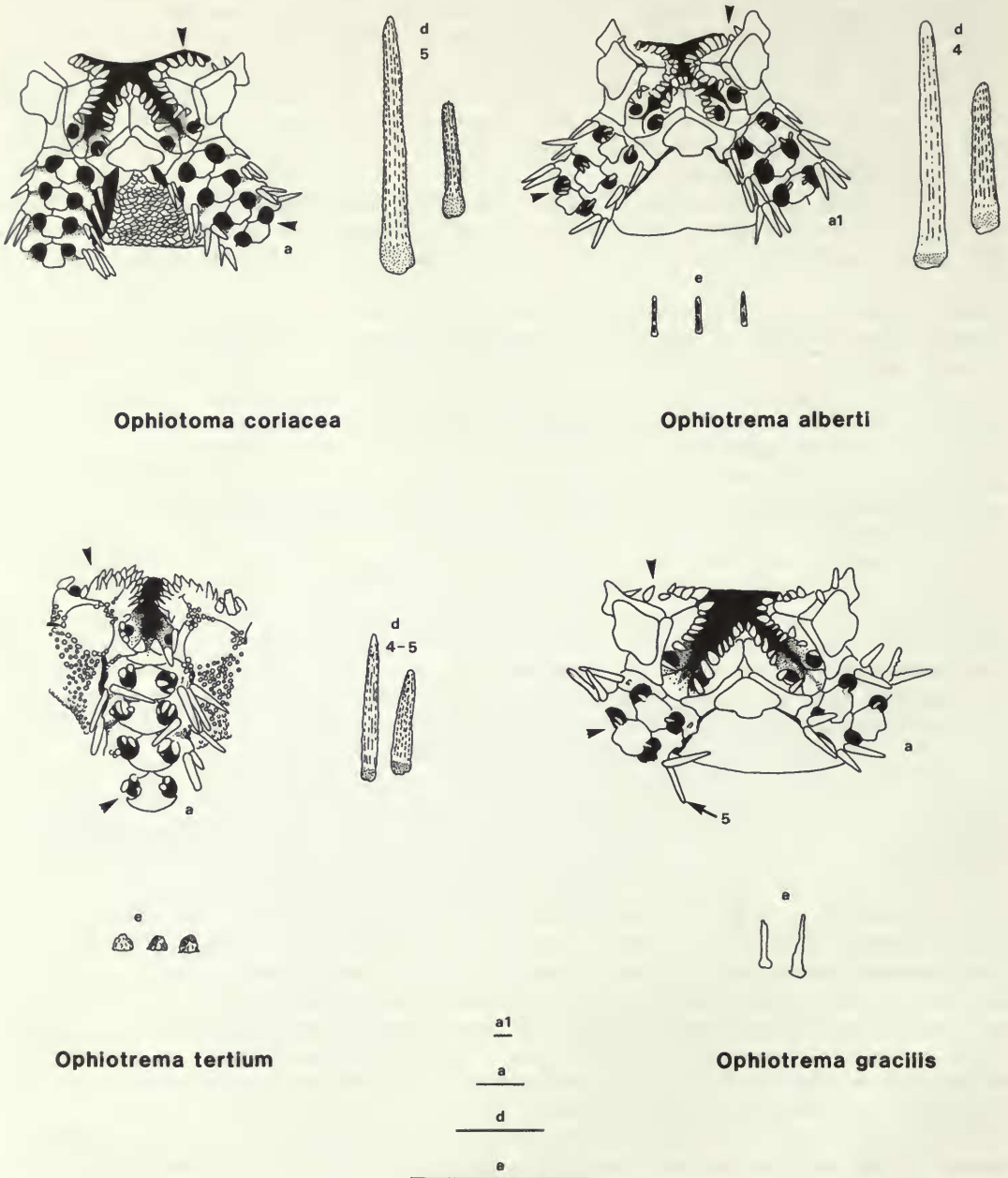
In transferring *O. hirsuta* H. L. Clark confused two distinct genera. *O. hirsuta* is distinctly a Ophiotominid not an *Ophiacantha* and I therefore propose to re-establish the genus *Ophiopristsis*.

*Ophiopristsis* may be defined as follows: the jaw longer than broad with one or two apical papillae flanked on each side by 4 or more rounded or slightly pointed oral papillae which form a continuous series with 2–4 slightly larger tentacle scales associated with the second oral tentacle pore, these scales may arise on the adoral shields, in some species there may also be papillae on the inner edge of the first ventral arm plate, the adoral shields long and narrow separating the oral shield from the first lateral arm plate; disk covered by small scales each bearing a spinelet; radial shields covered and inconspicuous; tentacle pores of the arm not open but armed with one or two leaf-like or scale-like tentacle scales. Species included are: *Ophiopristsis hirsuta*-type, (Fig. 24) *Ophioprium axiologus* H. L. Clark, 1909.

*Ophiopristsis* differs from *Ophioprium* as follows the oral tentacle scales are not markedly different from the oral papillae—those of *Ophioprium* are much more elongate and slightly separated; the tentacle pores are smaller and armed with 1–2 large tentacle scales whereas the pores in *Ophioprium* are open and armed with small thin tentacle scales.

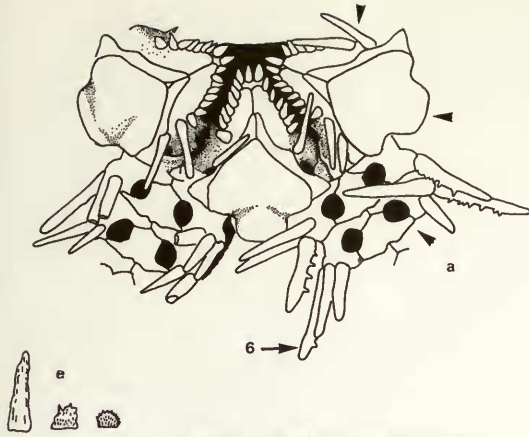
*Ophiopristsis* does seem to be similar in appearance to *Ophiologimus* H. L. Clark, 1911 but differs mainly in the form of the tentacle pore which is slightly smaller with larger tentacle scales than *Ophiologimus*. The relationship between *Ophiopristsis* and some species assigned to *Ophiotreta* needs to be investigated.

## OPHIACANTHIDAE : OPHIOTOMINAE

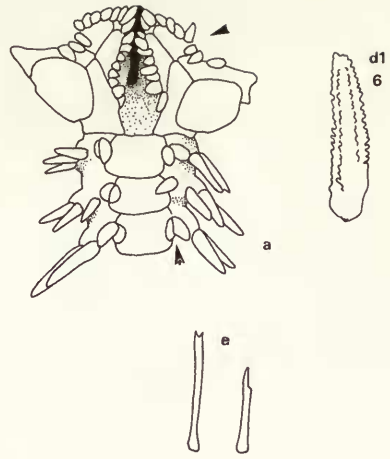
**Ophiotoma coriacea****Ophiotrema alberti****Ophiotrema tertium****Ophiotrema gracilis**

**Fig. 23** Key to the Ophiacanthidae: Ophiotominae. *Ophiotoma* and *Ophiotrema*: (a) ventral view of disk; (d) arm spines. A number with this figure indicates the number of proximal arm spines. The larger spine is a dorsal spine; the smaller a ventral spine; in figures with only one spine it is the dorsal one. (e) Disk spinelets. NB. In some figures the ventral interradiar area has been left blank for clarity. Bar scales = 1 mm, letters above the bars refer to the figures.

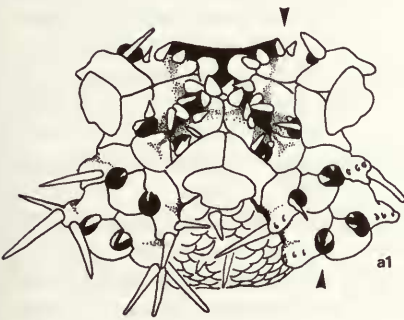




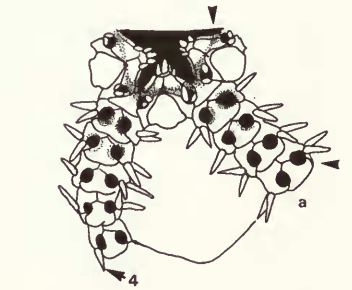
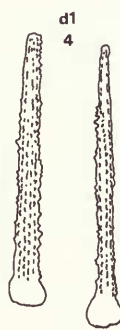
**Ophioprium permixta**



**Ophiopristis hirsuta**



**Ophiomedeia duplicata**



**Ophiocymbium cavernosum**

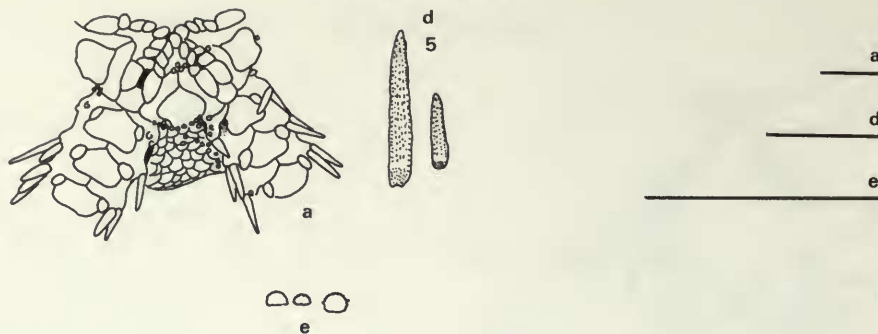


**Ophiolimna bairdi**



a  
 d, a1  
 e, d1

**Fig. 24** Ophiacanthidae: Ophiotominae. *Ophioprium*, *Ophiopristis*, *Ophiomedeia*, *Ophiocymbium* and *Ophiolimna*. Captions as in Fig. 23.



### *Ophiolimna opercularis*

Fig. 25 Ophiacanthidae: Ophiotominae. *Ophiolimna*. Captions as in Fig. 23.

*Ophioprium* is now defined as follows: the jaws longer than wide with one or two large apical papillae flanked on each side by 4–6 pointed oral papillae distal to which up to 4 elongated spine-like tentacle scales associated with the second oral tentacle pore, the distal scales markedly distinct from the oral papillae; the adoral shields long narrow often partially overlain by the large oral shield; disk covered by scales obscured by dense covering of spinelets and or granules; radial shields covered and inconspicuous; tentacle pores of the arm open armed with 1–2 long thin tentacle scales.

Species included are: *Ophioprium cervicornis* (Lyman 1883)—type species, *Ophiopristis permixta* Koehler, 1914 (Fig. 24), and *Ophioprium imperfectum* H. L. Clark, 1915.

The reasons for excluding *Ophiacantha rosea* Lyman are dealt with under that species. The species described by Baker (1979) do not appear to belong in this genus. They lack the elongated jaw, the two sets of papillae i.e. the oral papillae and markedly different oral tentacle scales and while the tentacle pores are relatively large, they are not open but are armed with 1–2 large tentacle scales. The figures and description suggest affinities with *Ophiotreta* or possibly *Ophiopristis*.

The genus *Ophioprium* shares several characters with *Ophiophiura*, *Ophiotrema* and possibly *Ophiotoma* and *Ophioblenna*. In particular the two distinct forms of papillae on the jaw, open tentacle pores and small tentacle scales. Differences between them centre on the covering of the disk, numbers of tentacle scales, arm spine number and shape. It is likely that in several instances such differences will be specific not generic.

### Summary of proposed changes

Usage as in H. L. Clark (1915), Baker (1979) and Baker & Devaney (1981)

Proposed usage

*Ophioprium cervicornis*  
*Ophioprium permixta*  
*Ophioprium imperfectum*  
*Ophioprium axiologia*  
*Ophiacantha hirsuta*  
*Ophioprium larissae*

*Ophioprium cervicornis*  
*Ophioprium permixta*  
*Ophioprium imperfectum*  
*Ophiopristis axiologia*  
*Ophiopristis hirsuta*  
*Ophiotreta? larissae*  
 or *Ophiopristis?*  
*Ophiotreta? kalalae*  
 or *Ophiopristis*  
*Ophiacantha rosea*

*Ophioprium kalalae*

*Ophioprium rosea*

*Ophiotoma coriacea* Lyman, 1883

Fig. 23

*Ophiotoma coriacea* Lyman, 1883: 227–287; Farran, 1913: 45; Mortensen, 1927: 187; 1933a: 39–41.

MATERIAL STUDIED. MCZ: Blake Stn 308 E. off Cape Cod 1242 m HOLOTYPE.

COB: BIOGAS HZ CV06 2200 m 1 specimen; BIOGAS Stn 1 CP27 1920 m 1 specimen; BIOGAS Stn 3 DS 30 4106 m 1 specimen.

The disk is round up to 17 mm disk diameter, and appears to be covered with skin but in dry specimens small scales can be seen through this covering. Small granules are scattered over the surface some developed into low spinelets. Only the distal tips of the radial shields are visible. The ventral interradial areas are similar to those of the dorsal side but the scales are usually more conspicuous.

The jaws appear to be longer than wide. There are up to three rounded blunt apical papillae flanked on either side by 6–7 oral papillae, the proximal ones are blunt but the distal ones are more spine-like. The series of oral papillae is separated from the 2–3 small blunt oral tentacle scales situated on the proximal edge of the adoral shields—these scales are much smaller than the oral papillae. The adoral shields are long with a straight proximal edge and widening distally so that they separate the oral shield from the first lateral arm plate. The oral shield is a large, rounded arrow shape.

The arms do not appear to be noded. The dorsal arm plates are slightly fan shaped, and contiguous on at least in the proximal segments; in some specimens the most proximal plates are slightly irregular and may be smaller than those on the rest of the arm. The ventral arm plates are irregularly pentagonal; with an obtuse proximal angle, indented lateral sides and a curved or indented distal edge; they are separated. The tentacle pores are large and open without tentacle scales. There are 5 simple arm spines proximally, 4 distally.

REMARKS. *O. coriacea* superficially resembles *Ophiotrema alberti* from which it differs by the lack of distinct spinelets on the disk; the shape of the adoral shields which are straight and do not have an indented proximal edge while those of *Ophiotrema alberti* are more wing-like and indented over the second oral tentacle pore; the shape of the oral shields which are arrow shaped not round and almost hemispherical as in some specimens of *Ophiotrema* and by the absence of tentacle scales in *Ophiotoma*. *Ophiotoma coriacea* bears a close resemblance to the ophiomyxid *Ophioscolex purpureus*. It differs from *Ophiotoma* in having one distinct tentacle scale, only 3 as opposed to 4–5 arm spines the proximal arm spines are transformed into hooks, the ventral arm plates are more rounded and pentagonal, and are contiguous at least proximally.

H. L. Clark (1915) considered that *O. coriacea* is conspecific with *O. bartletti* Lyman, 1883. As all that remains of the type specimen in the MCZ Harvard are fragments of the arms this cannot be confirmed. Accordingly it is proposed to retain the name *Ophiotoma coriacea* for this species.

DISTRIBUTION. It has been recorded from both sides of the North Atlantic: in the west off Cape Cod at a depth of 1242 m and in the east off Iceland south to the Azores in depths of 1765–4106 m.

*Ophiotrema alberti* Koehler 1896c

Fig. 23

*Ophiotrema alberti* Koehler, 1896c: 251; 1906: 6; 1907: 295; 1907b: 142; 1908: 612; 1909: 196–198; Matsumoto, 1915: 67; Gage *et al.* 1983: 288.

MATERIAL STUDIED. MNHN: *Travailleur & Talisman* 1883 Stn 134 38°9'N; 25°36'W 4010 m SYNTYPE.

COB: BIOGAS Stn 3: CV13 4252 m 2 specimens. CYMOR-2 DR29 2 specimens. INCAL: WS08 4287 m 2 specimens; WS10 4354 m 1 specimen; CP01 2068 m 2 specimens; CP16 4262 m 2 specimens; ØS05 4297 m 1 specimen.

SMBA: RRS *Challenger II*: Stn AT 192 57°21'N; 12°02'W 1862 m 2 specimens.

The disk is subpentagonal and covered with small thin scales many of which carry a simple glassy spinelet or rod, disk diameter up to 15 mm. The tips of the radial shields are sometimes visible and are rounded pear drop shaped. The disk is very delicate and often damaged particularly in the centre. The ventral interradial areas are covered with small plates armed with simple rods like those of the dorsal surface.



The jaw appears longer than broad. There may be one or more apical papillae flanked on each side by 4 or 5 oral papillae on the jaw edge. These papillae form an almost continuous series with 4 or 5 similar papillae associated with the second oral tentacle pore. In some specimens the latter papillae are much more developed forming a line along the proximal edge of the adoral shields. The second tentacle pore arises superficially. The adoral shields are wing-like with the proximal edge indented opposite the second oral tentacle pore and separate the oral shield from the first lateral arm plate. The oral shield is large, nearly hemispherical, with a rounded proximal edge and a slight distal lobe.

The arms are not particularly noded. The dorsal arm plates are triangular to bell shaped, and separated from one another. The ventral arm plates are nearly rectangular with a very obtuse proximal angle and a slight indent in the distal edge; they are nearly contiguous on proximal arm segments. The tentacle pores are large and the tube feet appear to be unretractable. The tentacle scales are small and variable, numbering from 0–5, some are needle-like while others resemble small granules. There are 4 glassy, smooth arm spines, slightly flattened with a rounded tip. The dorsalmost arm spine appears to be the longest up to 2 arm segments long.

**REMARKS.** *O. alberti* is similar to *O. gracilis* Koehler, 1914 (Fig. 23) from the West Indies (Albatross Stn 2751 16°54'N: 63°12'W 1236 m) the main differences appear to be the arrangement of the oral papillae and tentacle scales which are more regularly arranged in *O. gracilis* not forming an irregular line along the edge of the adoral shields. The oral shield is distinctly arrow shaped in *O. gracilis*. However, these differences may be just infraspecific but until more specimens are recovered from the western Atlantic it is better to recognise both.

**DISTRIBUTION.** This species has been recorded from the Rockall Trough, the Bay of Biscay and off the Azores with a bathymetric range of 1862–4252 m.

*Ophiotrema tertium* Koehler, 1922a  
Fig. 23

*Ophiotrema tertium* Koehler, 1922a: 88–91.

**MATERIAL STUDIED.** COB: BIOVEMA CP03 10°47'13N: 42°41'01W 5127 m 1 specimen.

The disk is pentagonal; often very damaged; covered with granules and sometimes lanceolate spinelets; disk diameter up to 15 mm. The ventral interradial area is also covered with granules, if spinelets are present they are usually confined to the distal edge.

The jaws appear to be longer than broad. There are 1–4 pointed apical papillae flanked on each side by 4–5 pointed oral papillae; there are 2, sometimes more larger tentacle scales associated with the second oral tentacle pore, distal to be oral papillae. The adoral shields are partially overlaid by the oral shield, flared distally, and often obscured by thickened skin and scattered granules. The oral shield is large, rounded triangular.

The arms are not particularly noded. The dorsal arm plates are fan-shaped, sometimes contiguous. The ventral arm plates are axe shaped and sometimes contiguous. The tentacle pores are large armed with 5 or more tentacle scales whose shape varies from thin and pointed to scale-like. There are 4–5 finely rugose arm spines; the second dorsalmost spine is the longest up to 2 arm segments long.

**REMARKS.** *O. tertium* can easily be distinguished from the other two species of *Ophiotrema* by the covering of the disk and the shape of the ventral arm plates.

The Biovema specimen differs from the type description in that the disk covering is comprised only of granules and in the shape of some of the tentacle scales. However, a lack of material prevents a study of the variation of such characters and as there is an overall similarity it is best not to describe this specimen as a new species.

**DISTRIBUTION.** *O. tertium* has been recorded from the Pacific off the Philippine Islands at a depth of 1335 m, and from the North Atlantic from the Vema Fracture zone at 5127 m.

*Ophiomedea duplicata* Koehler, 1906  
Fig. 24

*Ophiomedea duplicata* Koehler, 1906: 19–21; 1907: 280; 1922: 97.

**MATERIAL STUDIED.** MNHN: *Travialleur & Talisman* 25 Juin 1883 No. 43 29°52'N: 14°4'W 2075 m 1 specimen HOLOTYPE.

The disk is rounded to pentagonal, diameter up to 5 mm covered with thin overlapping scales many of which carry a simple rodlike spinelet. The spinelets are finely rugose. The radial shields may be visible, they are small irregular in shape and are as wide as long. The ventral interradial areas are covered by scales similar to those of the dorsal side, these scales also carry rod like spinelets.

The jaws appear to be wide as long. The surface of the jaw is indented about a third from the tip. There is one large blunt apical papilla flanked by 3–4 oral papillae irregularly arranged on each side; those nearest the apical papillae are conical the distalmost ones may be more spine-like. Sometimes the oral papillae form a continuous series with the tentacle scales of the second oral tentacle pore. Alternatively the tentacle scales may lie above the distal oral papillae. The second oral tentacle pore is superficial and is armed with 2–3 tentacle scales, the distalmost of these is large and spine-like. The adoral shields are large occupying a large portion of the jaw proximal to the oral shields. They are not particularly wing-like but separate the oral shield from the first lateral arm plate. The oral shield is rounded, rhombic but sometimes with a slight distal projection; the proximal edge is often complete rounded and not angular.

The arms are distinctly noded. The dorsal arm plates are triangular and separated. The first ventral arm plate is pentagonal with the lateral edges raised forming a boundary lip to the second oral tentacle pores. The subsequent ventral arm plates are pentagonal to bell shaped, separated with a wide curved distal edge and indented lateral edges. The tentacle pores are large and open, each is armed usually with two spine-like tentacle scales, the inner one of the two is the larger. There are 5–6 simple, finely rugose arm spines, the dorsalmost spine is the largest.

**REMARKS.** *Ophiomedeia duplicata* may be mistaken for a juvenile *Ophiotrema alberti*, it differs from that species by the following characters: the jaw shape is as wide as long not longer than wide as in *O. alberti*; there are fewer oral papillae and oral tentacle scales than in *O. alberti*, the ventral arm plates are bell shaped with a distinctly widened distal edge, the ventral arm plates of *O. alberti* being more pentagonal or rectangular with rounded edges and the distal edge indented but not widened. *O. duplicata* also resembles *Ophiocymbium cavernosum* but differs by having spine-like not block-like oral papillae, differently shaped oral and adoral shields.

**DISTRIBUTION.** *Ophiomedeia duplicata* has been rarely encountered, recorded only from the type locality off the Canary Islands at a depth of 2075 m.

### *Ophiocymbium cavernosum* Lyman, 1880

Fig. 24

*Ophiocymbium cavernosum* Lyman, 1880: 7; 1882: 162–163.

**MATERIAL STUDIED.** BMNH: HMS *Challenger* Stn 157 53°55'S: 108°35'E 3566 m HOLOTYPE.

COB: BIOGAS Stn 4: CP15 4715 m 1 specimen; DS79 4715 m 1 specimen. INCAL: WS05 4796 m 3 specimens; WS9 4277 m 2 specimens; WS10 4354 m 5 specimens; CP08 2644 m 1 specimen; CP13 4800 m 4 specimens; DS16 4262 m 6 specimens; ØS 04 4796 m 4 specimens; ØS 05 4296 m 1 specimen; ØS 07 4249 m 2 specimens; ØS 08 4327 m 4 specimens.

The disk is round flexible, rather bag-like, diameter up to 9 mm; covered by small thin semi-transparent scales some of which carry low granules. The radial shields are indistinct. The ventral interradial areas are similar to the dorsal surface.

The jaws are slightly wider than long. There are 3 prominent spine-like papillae on the oral plate with 2 rudimentary block like papillae on each side of the jaw. The second oral tentacle pore emerges superficially and is armed with 2 flat, blunt, spine-like papillae arising on the adoral shields and 1 small block-like papillae arising at the junction of the first ventral arm plate and the adoral shield. The adoral shields are partially overlain by the oral shield obscuring their proximal suture, distally the adoral shields are slightly flared and separate the oral shield from the first lateral arm plate. The oral shield is large, triangular in shape with a slight distal projection.

The arms are only slightly noded. The dorsal arm plates are triangular and separated from one another. The ventral arm plates are axe shaped; thin proximally but flaring out with a wide convex distal edge and only contiguous on the first few arm segments. The tentacle pores are large, open, only the first few may have tentacle scales which are usually thin and spine-like. There are 4 simple glassy spines of which the dorsalmost is the largest, nearly a segment long.



REMARKS. *O. cavernosum* is characterised by the structure and armament of the jaw, the open tentacle pores and the simple arm spines. Only *Ophiomedeia duplicata* bears any resemblance to it but *O. duplicata* can be distinguished by the spine-like oral papillae not block-like papillae as in *Ophiocymbium*; the adoral and oral shields differ in shape while the arm spines are rugose not smooth and glassy as in *Ophiocymbium*.

DISTRIBUTION. *Ophiocymbium cavernosum* is a little known ophiuroid previously only recorded from east of Kerguelen Islands, Southern Ocean, its discovery in the Bay of Biscay marks an exciting extension of range perhaps accountable to the considerable depth at which this species is found.

*Ophiolimna bairdi* (Lyman, 1883)

Fig. 24

*Ophiacantha bairdi* Lyman, 1883: 70–72; Lütken & Mortensen, 1899: 9–13; Koehler, 1907: 289; H. L. Clark, 1911: 230; 1915: 106; Mortensen, 1927: 188, 190; 1932: 27; 1933a: 30–31.

*Ophiolimna bairdi*: Verrill, 1899a: 40, 44; 1899b: 346; Matsumoto, 1917: 101–102 Djakanov, 1954: 32–33; Baranova, 1957: 189; Fell, 1960: 17.

MATERIAL STUDIED. MCZ: *Blake* Stn 308 Off Cape Cod 2235 m PARATYPE.

COB: BIOGAS Stn 1: CV10 2108 m 1 specimen; 1 CP02 2177 m 1 specimen; CV39 2350 m 1 specimen; CP26 2115 m 1 specimen; DS16 2325 m 1 specimen; DS18 2138 m 2 specimens; DS32 2138 m 1 specimen. BIOGAS Stn 2: CP09 1 specimen. BIOGAS Stn 6: CV16 1909 m 1 specimen; CP25 1985 m 5 specimens; DS26 2076 m 4 specimens. INCAL: DS03 609 m 1 specimen.

IOS: *Discovery* Investigations: Stn 8511/2 41°49'6"N: 11°6'0"W 2574–2584 m 2 specimens.

SMBA: RRS *Challenger II*: Stn ES 118 54°39'N: 12°14'W 2910 m 1 specimen.

The disk is round to sub pentagonal, diameter up to 11 mm, covered with elongated granules and spines. The disk is often damaged with the central portion of the disk missing. Only the tips of the radial shields are sometimes visible. The ventral interradiation areas are covered with granules like those of the dorsal surface.

The jaws appear large, slightly longer than wide. There is one, sometimes two, pointed apical papilla flanked on each side by 5–6 oral papillae, the proximal ones are pointed similar in shape to the apical papilla but distally they become rounded, and the distalmost one is large and opercular. The adoral shields are very wing-like and separate the oral shield from the first lateral arm plate. At the proximal suture of the shields there is often a cluster of granules. The oral shield is large and is approximately triangular in shape.

The arms are noded. The dorsal arm plate are bell shaped and contiguous. The ventral arm plates are approximately pentagonal, the lateral sides are indented with the distal edge convex, and are contiguous. The tentacle pores are quite large each is armed with a rounded or slightly pointed scale-like tentacle scale. The lateral arm plates, ventral arm plates and tentacle scales are distinctly striated. There are 6 arm spines. They do not form a fan on proximal arm segments.

REMARKS. *Ophiolimna bairdi* can be easily recognised by its large triangular oral shields, granules and simple spines on the disk, granules on the adoral shields, striations on the lateral and ventral arm plates.

DISTRIBUTION. This species is perhaps of Arctic origin which is also found in bathyal and abyssal depths of both sides of the North Atlantic: south to Martha's Vineyard in the west and from the Rockall Trough south to Portugal in the east.

*Ophiolimna opercularis* Koehler, 1907b

Fig. 25

*Ophiolimna opercularis* Koehler, 1907b: 43; 1909: 191–192.

*Ophiacantha opercularis*: Mortensen, 1927: 190.

MATERIAL STUDIED. MOM: *Princesse Alice* 1901 Stn 1173 12°7'N: 33°33'W 6035 m HOLOTYPE.

The disk is round covered with a dense coating of low hemispherical granules which extend on to the ventral interradiation area; disk diameter is 4 mm.

The jaws appear to be longer than broad. There is one rounded apical papilla flanked on each side by up to 5 oral papillae, the distalmost of which is large, rectangular and opercular. The adoral shields are large, slightly flared distally and separating the oral shield from the first lateral arm plate. Scattered granules are often present on the jaw plates and on parts of the adoral shields. The oral shield is approximately rounded triangular, often with an acute proximal angle and a distal projection.



The arms are not particularly noded. The dorsal arm plates are slightly bell shaped or fan shaped, they approach but are not quite contiguous. The first ventral arm plate is pentagonal, subsequent ones are rounded pentagonal with an obtuse proximal angle and a convex distal edge, only the first and second ventral arm plates are contiguous. The tentacle pores are relatively large armed with one rounded tentacle scale. There are 5 finely rugose arm spines, distally only 3; the spines approach but do not form a fan on the proximal arm segments. The dorsal, lateral, and ventral arm plates are distinctly striated.

REMARKS. *O. opercularis* is very similar to *O. bairdi* suggesting that any differences may be due to infraspecific variation. However, until more specimens of *O. opercularis* are available it is best to regard them as distinct.

*O. opercularis* can be distinguished from *O. bairdi* by the disk bearing only low granules, the shape of the oral shield which is more rounded, the shape of the proximal oral papillae which are more rounded than those of *O. bairdi*, finally the tentacle pore is smaller—although this may be due to the small size of the specimen.

DISTRIBUTION. One specimen of this species has been recorded, from the Cape Verde Basin, SW. of the Cape Verde Is at 6035 m.

### OPHIOPLINTHACINAE Subfamily Nov.

DIAGNOSIS. A subfamily of the Ophiacanthidae with well developed disk plates or enlarged disk scales; the disk sometimes indented interradially and often high; the radial shields forming part of the disk, often quite long but not bar-like and hidden by the disk plates; jaws as broad as long; one apical papilla flanked on each side by up to six oral papillae found in most genera except *Ophiocamax* and *Ophiomitra* which have multiple apical and oral papillae; oral tentacle pore not superficial and without conspicuously modified tentacle scales; oral shield small to medium in size; the tentacle pores of the arm not conspicuously large and always armed with at least one tentacle scale; arm spines usually long, the longest equal in length to at least 2 arm segments.

TYPE GENUS. *Ophioplinthaca* Verrill, 1899a with type species *O. dipsacos* (Lyman, 1878).

REMARKS. Genera included in this subfamily are: *Microphiura* Mortensen, 1911; *Ophiocamax* Lyman, 1878; *Ophiocopa* Lyman, 1883; *Ophiodictys* Koehler, 1922a; *Ophiomitra* Lyman, 1869; *Ophiomitrella* Verrill, 1899a; *Ophiomytis* Koehler, 1904 '*Ophiophthalmus*' Matsumoto, 1917, an invalid junior homonym of *Ophiophthalmus* Fitzinger, 1843, a Reptile; *Ophioplinthaca* Verrill, 1899a; *Ophioripa* Koehler, 1922a; *Ophiothamnus* Lyman, 1869; *Ophiurithamnus* Matsumoto, 1917.

*Ophioplinthaca* has been chosen as type genus because it shows the greatest and therefore most unambiguous development of the characters which separate this subfamily from the others but from the Ophiacanthinae in particular. These characters: the large size of the disk plates and the integration of the whole radial shield in the plating of the disk, appears to be constant throughout the group. There does not appear to be a graduation from the small semi-transparent scales of the Ophiacanthinae to the larger, well developed, plates of the Ophioplinthacinae.

Within the Ophioplinthacinae the characters used to distinguish the genera are the shape and position of the radial shields, the shape of the disk whether or not it is indented and the form and number of both the apical and oral papillae, the arrangement of the adoral and oral shields and the degree of development of the dorsal arm plates. While the Ophioplinthacinae as a whole apparently forms a well-differentiated subfamily group many of the genera included appear ill-defined. *Ophiomitrella*, *Ophioripa*, '*Ophiophthalmus*' and *Ophiomelina* are distinguished on characters which elsewhere in the Ophiacanthidae would be used as specific characters. For example, the differences cited by Matsumoto (1917) to distinguish '*Ophiophthalmus*' from *Ophiomitrella* were the contiguous proximal dorsal arm plates and the absence of a fan arrangement of arm spines on the proximal arm segments. Koehler (1922) distinguished these two also by the character of the imbricating disk plates and round naked radial shields. However, two

species of *Ophiomitrella*, *O. clavigera* and *O. globifera* show most of the features of '*Ophiophthalmus*' except for having contiguous dorsal arm plates. In species like '*Ophiophthalmus granifera* Koehler, 1922 and *O. cataleimmoidea* (H. L. Clark, 1911) the proximal dorsal arm plates are only just contiguous. Even within this genus Koehler (1922) was able to distinguish three groupings. If doubt is cast on the taxonomic validity of the generic grouping called '*Ophiophthalmus*' then *Ophiomitrella*, *Ophioripa* and *Ophiomelina* must also be suspect. Other nominal genera which should be investigated include *Ophiothammus-Ophiurothammus* and *Ophioplinthaca-Ophiomytis*.

No new generic name has been proposed for '*Ophiophthalmus*' partly because there has been no opportunity to look at all the material but mainly because it remains to be demonstrated that it is distinct from the genus *Ophiomitrella* as stated before. Hopefully this problem will be solved when the group is thoroughly revised.

### *Ophioplinthaca chelys* (Wyville Thomson, 1877)

Fig. 26

*Ophiacantha chelys* Wyville Thompson, 1877: 64.

*Ophiomitra chelys*: Lyman, 1878: 64; 1882: 205.

*Ophioplinthaca chelys*: Verrill, 1889b: 352; Koehler, 1904: 131; 1906: 6; 1907: 294; 1909: 194.

MATERIAL STUDIED. **BMNH**: HMS *Challenger* Stn 84 30°38'N: 18°5'W 2056 m HOLOTYPE & PARATYPE. HMS *Challenger* Stn 3 25°45'N: 20°12'W 2789 m 3 specimens; HMS *Challenger* Stn 33 off Bermuda 796 m 2 specimens.

The disk is high and appears round but the interradial areas are deeply indented, diameter up to 10 mm; covered with large and conspicuous plates amongst which the centrodorsal plate can usually be distinguished. The disk has large granular spinelets, some of which are just rounded others with a crown of 3 or 4 points, scattered over the dorsal and ventral surfaces. The radial shields are long and thin, about 3–4 times as long as broad, separated from one another and recessed into the disk. They are slightly longer than half the disk radius. The ventral interradial areas are covered with large plates sometimes bearing a spinelet.

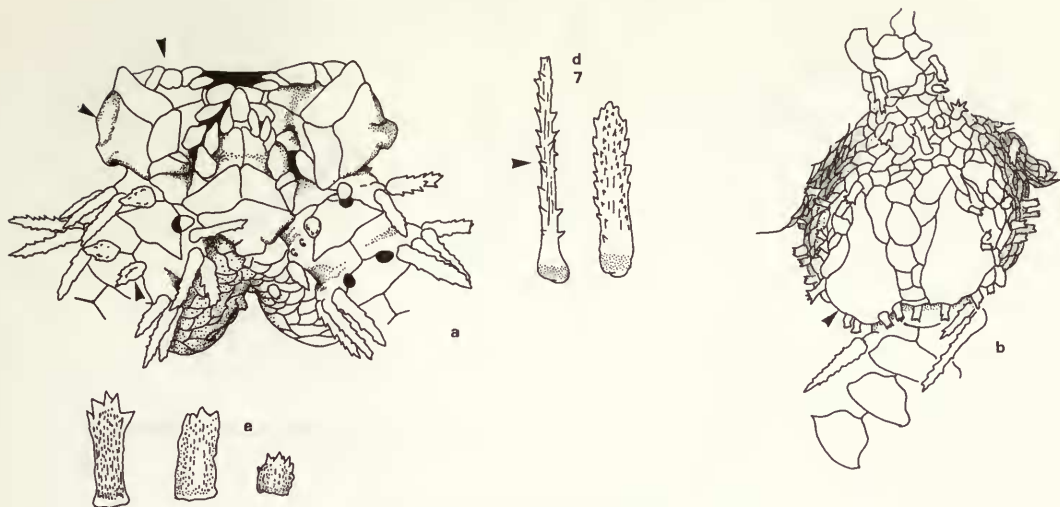
The jaws appear to be as long as broad or slightly longer. The apical papilla is large and blunt with 4 or 5 contiguous oral papillae. The proximal oral papillae are pointed and roughly leaf shaped, the distalmost papillae is distinctly triangular. The adoral shields are slightly convex occupy a large portion of the jaw proximal to the oral shield, not separating it from the first lateral arm plate. The oral shield is large and distinctly pentagonal, the proximal angle is often very acute.

The arms are distinctly noded. The dorsal arm plates are swollen, fan shaped and separated from one another. The ventral arm plates are wider than long broadly pentagonal in shape and separated from one another. The tentacle pores are relatively large, each is armed with a pointed tentacle scale. There are 6 arm spines on proximal arm segments, 4 on distal ones. The arm spines appear rugose due to very large secondary points on the shaft; the dorsalmost spines are the longest often 2 or more arm segments long; the ventralmost spines become sabre shaped distally. The arm spines do not form a fan on proximal arm segments.

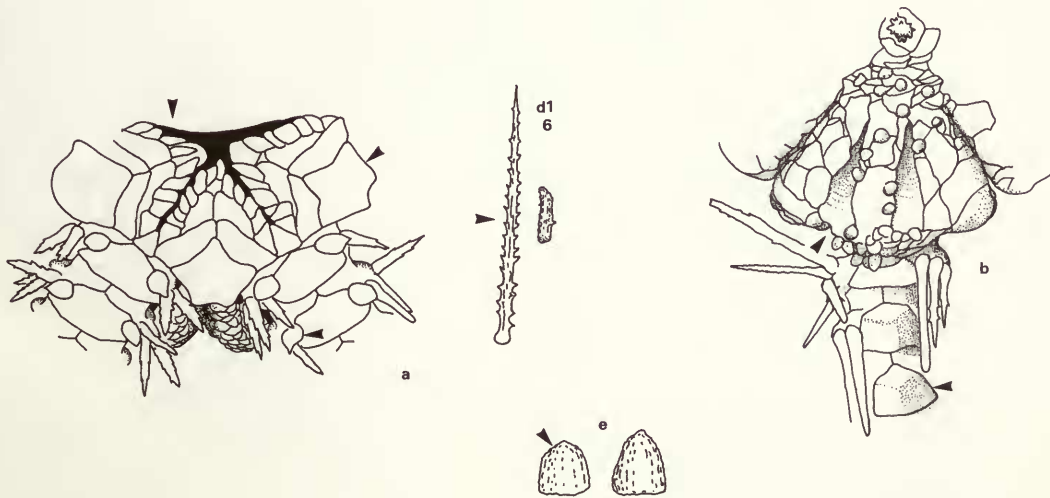
REMARKS. *Ophioplinthaca chelys* can be distinguished from *O. carduus* by its recessed radial shields lower more granule-like disk spinelets, more angular oral shields, contiguous oral papillae and smooth leaf-like tentacle scales. *O. chelys* differs from *O. abyssalis* in the following ways: the radial shields are separated and recessed into the disk while those of *O. abyssalis* are contiguous and not recessed; the oral papillae are contiguous and slightly angular; those of *O. abyssalis* are longer and more spinelike; the oral shield is pentagonal as opposed to slightly arrow shaped in *O. abyssalis*.

DISTRIBUTION. *O. chelys* has been recorded from both sides of the North Atlantic, in the west off Bermuda 796 m and in the east off Portugal south to the Canaries, with a bathymetric range of 2056–3307 m. Outside the Atlantic Koehler (1922a) records it from off the Philippines with a bathymetric range of 1165–2081 m.

**OPHIACANTHIDAE : OPHIOLINTHACINAE**



**Ophioplinthaca carduus**



**Ophioplinthaca chelys**

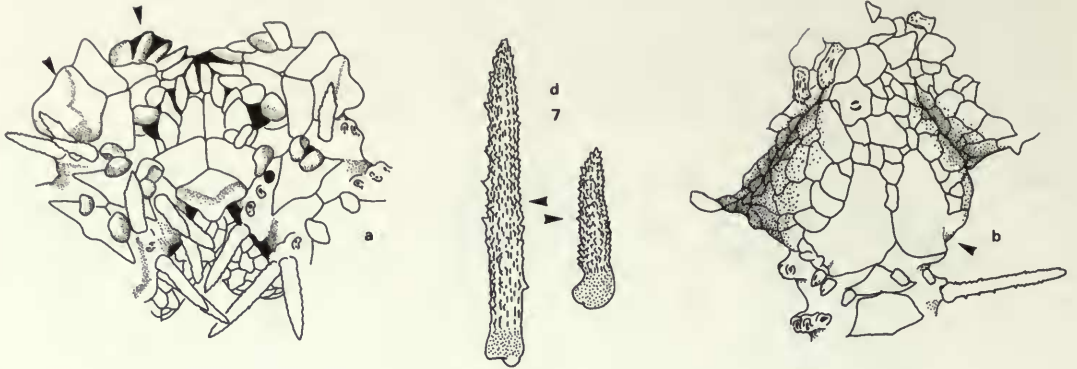
a, b, d1

d

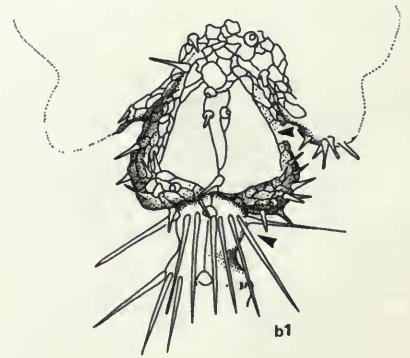
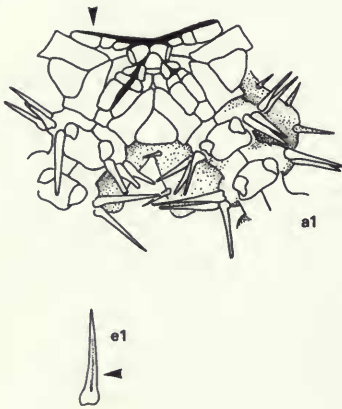
e

**Fig. 26** Key to the Ophiacanthidae: Ophioplinthacinae. *Ophioplinthaca*: (a) ventral; (b) dorsal view of disk; (d) arm spines—a number with this figure indicates the number of proximal arm spines. The larger spine is a dorsal spine, the small a ventral spine; in figures with only one spine it is the dorsal one. (e) Disk spinelets. NB. The ventral interradial area has been left blank in some figures for clarity. Bar scales = 1 mm, letters above the bars refer to the figures.





**Ophioplinthaca abyssalis**



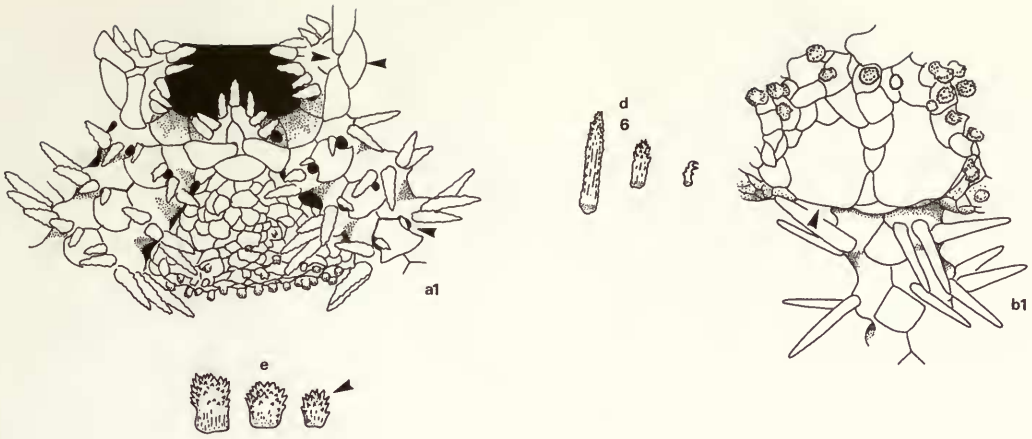
**Ophiothamnus affinis**

a, b

d, e1, b1

e, d1, e1

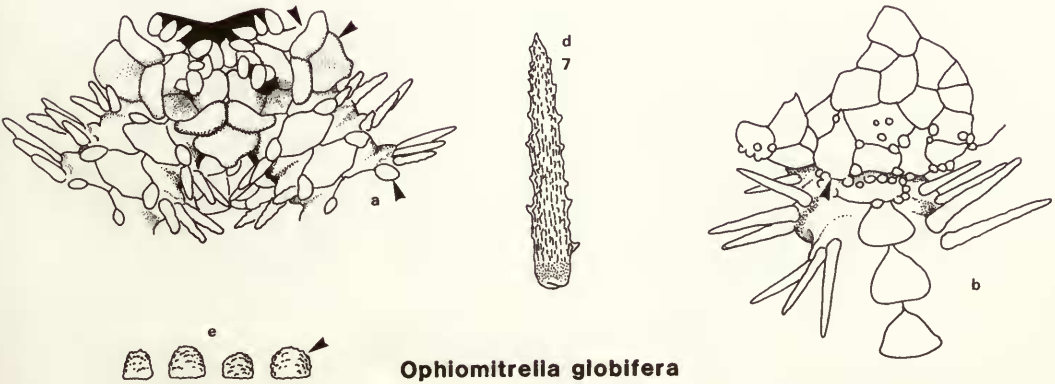
**Fig. 27** Ophiacanthidae: Ophioplinthacinae. *Ophioplinthaca*, *Ophiothamnus*. Captions as in Fig. 26.



**Ophiomitrella clavigera**

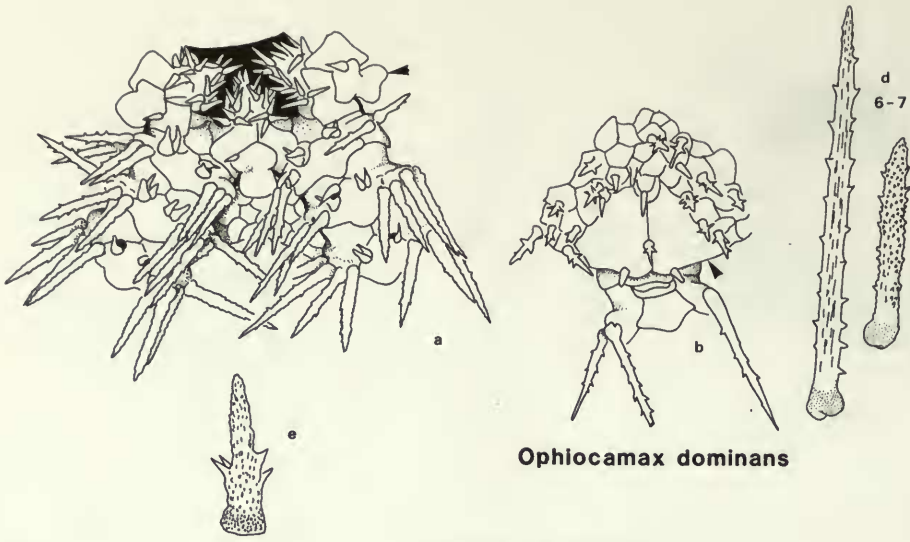


**Ophiomitrella cordifera**



**Ophiomitrella globifera**

Fig. 28 Ophiacanthidae: Ophioplithacinae. *Ophiomitrella*. Captions as in Fig. 26.



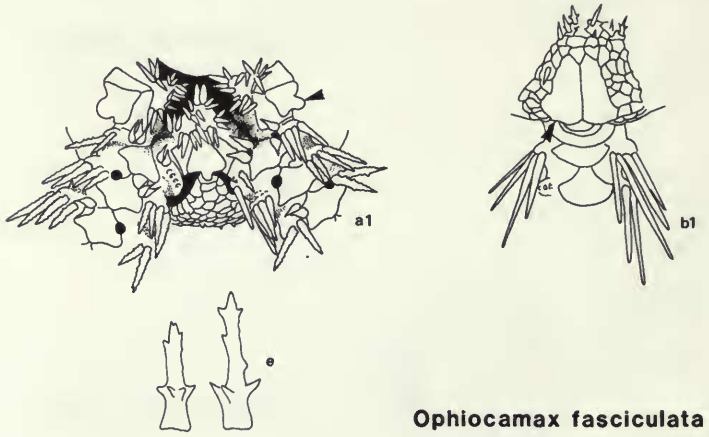
**Ophiocamax dominans**

a1, b1

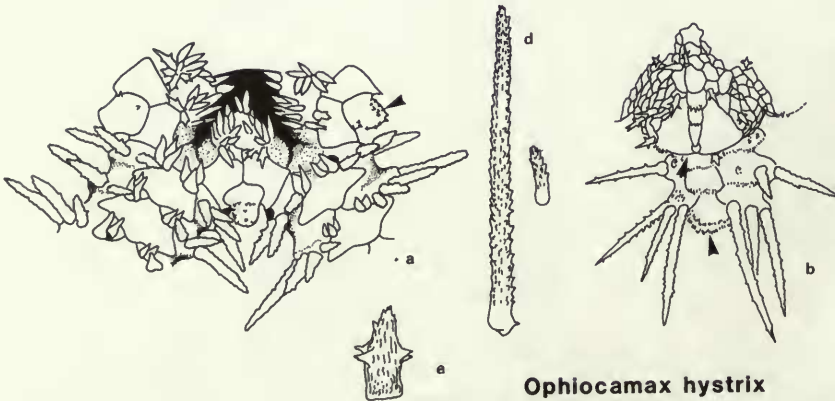
a, b

d

e



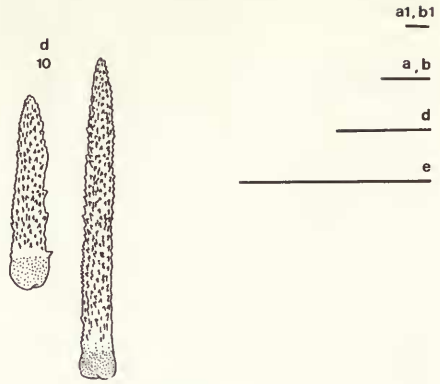
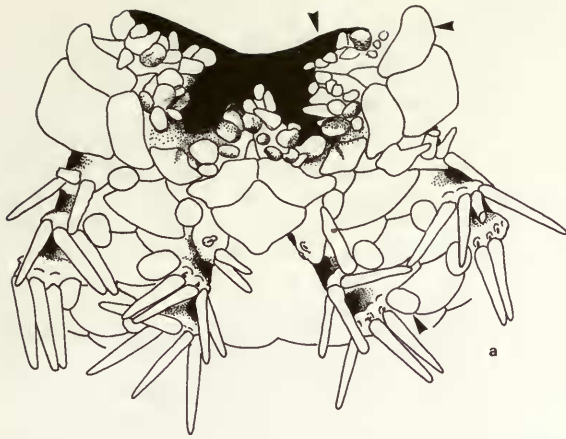
**Ophiocamax fasciculata**



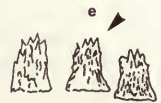
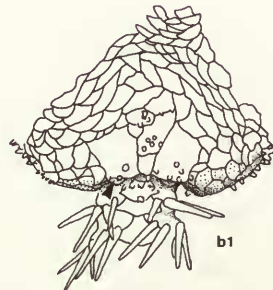
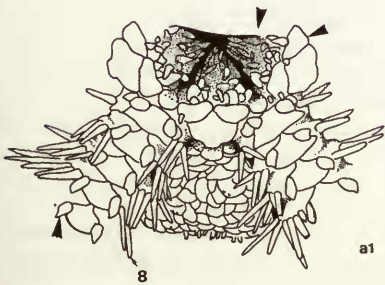
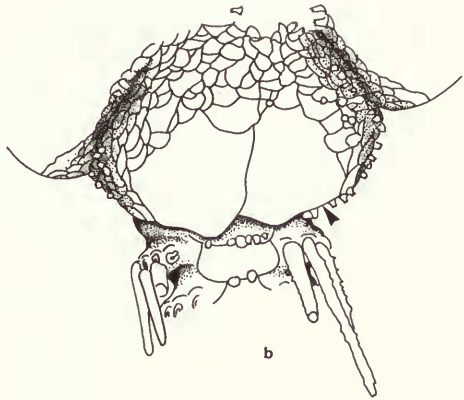
**Ophiocamax hystrix**

**Fig. 29** Ophiacanthidae: Ophioplinthacinae. *Ophiocamax*. Captions as in Fig. 26.





**Ophiomitra spinea**



**Ophiomitra hamula**

**Fig. 30** Ophiacanthidae: Ophioplithacinae. *Ophiomitra*. Captions as in Fig. 26.

*Ophiolithaca carduus* (Lyman, 1878)

Fig. 26

*Ophiomitra carduus* Lyman, 1878: 154.*Ophiolithaca carduus*: Verrill, 1899b: 35; Koehler, 1906: 6; 1907: 294.MATERIAL STUDIED. BMNH: HMS *Challenger* Stn 33 off Bermuda 796 m HOLOTYPE.

The disk is strongly indented interradially diameter up to 16.5 mm; covered by plates amongst which the centrodorsal is usually conspicuous. Many of the plates carry a spinelet which usually have multipointed tips, the shaft is usually straight but occasionally there are secondary points. The radial shields are irregularly tear drop shaped about twice as long as broad and separated along their entire length. The radial shields are slightly longer than half disk radius. The ventral interradial areas are covered with plates similar to those of the dorsal side, many of them carry spinelets.

The jaw appears to be as wide as long. There is one large, wide, blunt or slightly pointed apical papilla flanked on each side by 4–5 oral papillae, which are pointed with the distalmost one being the largest. The adoral shields are curved and situated proximal to the oral shield, not separating it from the first lateral arm plate. The oral shield is pentagonal to arrow head shaped. In pentagonally shaped plates there is often a distal tongue or lobe slightly lower than the rest of the plate.

The arms are distinctly noded. The dorsal arm plates are fan shaped, domed and are separated from one another. The ventral arm plates are basically triangular and separated from one another, the mid portion of the distal edge is raised up, sometimes quite acutely, forming a small hillock. The tentacle pores appear to be medium sized each is armed with a large, leaf shaped tentacle scale which becomes highly rugose on many pores. There are 7 arm spines proximally 4–5 on distal segments. The spines appear to be quite rugose with large secondary points on the shaft of the spine. The dorsalmost or second dorsalmost spine is usually the largest up to 2 arm segments long. The ventral arm spines are usually straight. The proximal arm spines do not form a fan.

REMARKS. Comparisons with the other North Atlantic species are given under *O. chelys*. *O. carduus* may be distinguished by the shape and position of the radial shields, the shape of the oral shield, the tentacle scale shape, the domed shaped dorsal arm plate and the rugose arm spines.

DISTRIBUTION. *O. carduus* has been recorded from off Bermuda 796 m in the Western Atlantic and from 30°17'N: 43°7'W 3500 m, on the Mid-Atlantic Ridge SW. of the Azores.

*Ophiolithaca abyssalis* Cherbonnier & Sibuet, 1972

Fig. 27

*Ophiolithaca abyssalis* Cherbonnier & Sibuet, 1972: 1368–1370

MATERIAL STUDIED. MNHN: Noratlante 132–D.12 47°41'07"N: 08°30'06"W 3100 m HOLOTYPE.

IOS: *Discovery* Investigations Stn 9042 42°15'N: 11°22'W 1662–1541 m 4 specimens.

The disk is high indented interradially, diameter up to 10 mm, covered with large irregularly shaped plates many of which are armed with finely rugose, large simple spinelets. The spinelets are largest in the centre of the disk. The radial shields are basically triangular in shape, pairs of shields are usually contiguous, at least distally. The radial shields are slightly less than half disk radius in length. The ventral interradial areas are covered with large plates like those of the dorsal surface, spinelets may be present.

The jaws are wider than long. There are one or two pointed or spine like apical papillae flanked by 3–5 oral papillae on each side. The proximal oral papillae are flattened and lanceolate while the distal ones are large rounded and slightly club shaped. Occasionally there are one or two supranumerary papillae, on the proximal edge of the adoral shield. The adoral shields are large, not particularly wing-like, restricted to the proximal sides of the oral shield, not separating it from the first lateral arm plate. The oral shield is slightly arrow shaped with an obtuse proximal angle and with a slight projection of the distal edge; the distal part of the plate is distinctly swollen in most specimens but in some the plate is flat.

The arms are noded. The dorsal arm plates are bell shaped and contiguous on the proximal arm joints. The ventral arm plates are pentagonal nearly triangular with a very wide distal edge; the distal edge may project slightly midradially. The ventral arm plates are separated. The tentacle pores are small; those of the first and sometimes the second arm segment armed with two large, rounded tentacle scales, the others only have one. There are 7 rugose arm spines on proximal segments 6 distally; the dorsal or second dorsalmost spine is usually the longest up to 2 arm segments in length. The ventral arm spines are more rugose than

the dorsal ones and slightly curved or sabre shaped. The arm spines do not form a fan on proximal arm segments.

REMARKS. *O. abyssalis* may be distinguished from the other North Atlantic species by the shape of the radial shields, the disk spinelets, the arrangement of the apical and oral papillae, the swollen oral shield, the flat dorsal arm plates and the shape of the tentacle scales.

DISTRIBUTION. *O. abyssalis* has been recorded from the Bay of Biscay and off NW. Spain in 1541–3100 m.

*Ophiomitra spinea* Verrill, 1885a

Fig. 30

*Ophiomitra spinea* Verrill, 1885a: 153; 1885b: 544; Mortensen, 1933a: 43–44.

MATERIAL STUDIED. USNM: *Albatross* Stn 2035 off Nantucket Shoals 2479 m HOLOTYPE.

COB: CYMOR DR 13 47°44'N: 8°35'14"W 3150 m 1 specimen.

The disk is round, indented interradially, high and the area of the radial shields is raised up, in diameter up to 13.5 mm. The disk is covered by small overlapping plates which are partially obscured by the dense covering of spinelets. The spinelets are low with a wide base and a trifold or rugose crown. The radial shields are naked. They are large nearly as wide as long, contiguous distally or just separated by a wedge of plates. The ventral interradiation areas are covered with small plates and spinelets similar to those of the dorsal side.

The jaws appear short, wider than long. There are several apical papillae flanked on each side by many oral papillae, it is difficult to distinguish the oral from the apical papillae. The oral papillae appear to be arranged in two series: a superficial series edging the side of the jaw and a series within the mouth slit which might be oral tentacle scales associated with the first and second oral tentacle pores. The adoral shields are convex, restricted to the proximal sides of the oral shield and not separating it from the first lateral arm plate. The oral shield is approximately rhombic with the centre of the plate slightly depressed.

The arms are slightly noded. The dorsal arm plates are fan shaped and contiguous proximally. The ventral arm plates are pentagonal, nearly triangular with a wide convex distal edge, and nearly contiguous on proximal segments. The tentacle pores are small, each is armed with one large flat leaf-like tentacle scale. There are 10 slightly rugose arm spines on proximal arm segments, 6–7 on distal ones. The spines approach but do not form a fan on proximal arm segments.

REMARKS. Mortensen (1933a) remarked that *O. spinea* was similar to *O. hamula* but as few specimens of either had been collected it was not possible to judge if they were conspecific. An examination of the type specimens together with those from the CYMOR suggest several differences which can be tested when more specimens are collected. *O. spinea* appears to differ from *O. hamula* in the following characters:

1. The disk is high, indented interradially whereas that of *O. hamula* is neither indented nor as high especially in the region of the radial shields.
2. The radial shields are large and contiguous or nearly so in *spinea* while they are quite small, usually separated and confined to the edge of the disk in *hamula*.
3. The granules of *spinea* have broad base and a trifold or slightly rugose crown, those of *hamula* have a narrower base and the crown is more rugose.
4. The jaw of *spinea* has rounded stubby oral papillae, those of *hamula* are more spinelike and the jaw itself appears to be sunken into the disk, not on the same level as the adoral shields. There is a slight indication of this in *spinea* but it is not as marked as in *hamula*.
5. The adoral shields are not as wing-like in *hamula* as those of *spinea*.

DISTRIBUTION. *O. spinea* has been recorded from both sides of the Atlantic, in the west from off Martha's Vineyard at a depth of 2479 m and in the east from the Bay of Biscay at a depth of 3150 m.

*Ophiomitra hamula* Mortensen, 1933a

Fig. 30

*Ophiomitra hamula* Mortensen, 1933a: 41–44.

MATERIAL STUDIED. ZMC: *Ingolf* Stn 64 62°06'N: 19°00'W 1874 m HOLOTYPE.



The disk is round to subpentagonal not deeply indented interventrally, disk diameter up to 8 mm. The disk is covered by conspicuous overlapping plates which in turn are covered by granule-like spinelets that appear quite rugose on close examination. The radial shields are quite small, nearly as wide as long, usually separated by a wedge of three or four plates but some shields may be contiguous at their distal ends. The ventral interradiar areas are covered by plates and granules like those of the dorsal side.

The jaws appear to be wider than long. There are several spine-like papillae at the apex of the jaw, distal to these papillae the jaw appears to be covered by irregularly spaced oral papillae which are smaller and more rounded than those at the apex. The jaw proximal to the adoral shields appears to be recessed into the mouth. The adoral shields are small slightly convex but not particularly wing-like, and restricted to the proximal edges of the oral shield, not separating it from the first lateral arm plate. The oral shield is rhombic with a slight distal lobe.

The arms are slightly noded. The dorsal arm plates are fan shaped to bell shaped and contiguous on proximal arm segments. The ventral arm plates are pentagonal with a wide distal edge, and contiguous on proximal arm segments. The tentacle pores are quite small each is armed with one flat leaf-like tentacle scale. On the first arm tentacle pores there are sometimes two scales. There are 8 arm spines on proximal segments, 7 on distal ones, the dorsal arm spines are finely rugose becoming rugose ventrally. They do not form a fan on proximal arm segments.

**REMARKS.** The differences between *O. hamula* and *O. spinea* are described under the Remarks section of *O. spinea*.

**DISTRIBUTION.** *O. hamula* has been recorded once from the south of Iceland, at a depth of 1874 m.

### *Ophiocamax dominans* Koehler, 1906

Fig. 29

*Ophiocamax dominans* Koehler, 1906: 21; 1907: 281.

**MATERIAL STUDIED.** MNHN: *Talisman* off Sahara 822 m HOLOTYPE & PARATYPE.

**IOS:** Discovery Investigations: Stn 8967 31°25'9"N: 10°53'7"W 1220–1140 6 specimens; Stn 9028 31°26'1 N: 10°52'8"W 1229–1166 m 3 specimens.

**COB:** CYMOR-2 DR2 47°47'N: 08°49'W 2600 m 1 specimen.

The disk is round or slightly indented interradially and domed; diameter up to 15 mm; covered by large plates each plate carrying at least one stout disk spine. In some specimens these spines may have been rubbed off but the area of attachment is usually visible. The disk spine may be simple or sometimes there is a collar of secondary points about a third of the way up the shaft. The radial shields are large, contiguous and extend half to three-quarters the radius of the disk. The ventral interradiar areas are similar to the dorsal side with larger plates but not all carry spinelets.

The jaw is typical of the genus with multiple spine-like apical papillae and oral papillae along its edge. The oral papillae appear to be arranged in three tiers. This is because the tentacle scales of the first and second oral tentacle pores are also spinelike, resembling the oral and apical papillae. The adoral shields are prominent and wing-like distinctly separating the oral shield from the first lateral arm plate. The oral shield has an irregular shape, although it may sometimes be hourglass shaped, and extends from the oral frame on to the interradiar area. In some specimens the distal portion may carry a spine.

The arms are distinctly noded. The dorsal arm plates are bell shaped, the proximal ones contiguous. The ventral arm plates are triangular with the mid portion of plate raised up. The tentacles are large, each is armed with up to 3 long spine-like tentacle scales, sometimes missing. There are 6–7 rugose arm spines. They do not form a fan on contiguous segments. The second to fourth dorsalmost spines are the longest, up to 3 arm segments long.

**REMARKS.** In the Atlantic *O. dominans* bears closest affinity with *O. fasciculata* Lyman, 1883, found off St. Kitts, Leeward Is (Fig. 29) but differs by the following characters: the plates of the disk are much larger and fewer in number than in *O. fasciculata*; the oral shield is irregular or hourglass in shape, not arrowhead shaped as in *O. fasciculata*, finally the shape of the tentacle scales simple and spine-like in *O. dominans* but leaf-like or with a broad base and an acute tip in *O. fasciculata*.

Another species likely to be found in the North Atlantic is *O. hystrix* Lyman, 1878, found off Havana, Cuba. (Fig. 29) *O. hystrix* may be identified by the very rugose nature of the dorsal arm

plates distal portion of the hourglass shaped oral shield and arm spines. The radial shields are often separated unlike those of the previous two species which are usually contiguous.

**DISTRIBUTION.** *O. dominans* has been recorded from off North Africa in 822–1229 m.

*Ophiomitrella clavigera* (Ljungman, 1864)

Fig. 28

*Ophiactis clavigera* Ljungman, 1864: 365.

*Ophiolebes clavigera*: Lyman, 1882: 201; Farran, 1913: 44; Mortensen, 1913: 361; H. L. Clark, 1915: 193; Grieg, 1921: 37.

*Ophiolebes acanellae* Verrill, 1885b: 548.

*Ophiomitrella clavigera*: Mortensen, 1920: 48–50; 1927: 186, 1933a: 40.

**MATERIAL STUDIED.** **BMNH:** Norman Collection, Norway. 1 specimen; Irish Fisheries Stn 483 51°37'N: 11°56'W 1098–1952 m 2 specimens; North Sea 1 specimen.

The disk is round to pentagonal, sometimes high, this feature may vary according to the position of the arms whether they are coiled under the disk; diameter is up to 6–7 mm usually smaller. The disk is covered with imbricating plates each carrying a club-like spinelet, the enlarged tip of which is rugose; in some specimens there are roughly two sizes of spinelet; the larger club-like spinelet and a smaller more granule-like spinelet. The radial shields are distinct separated or just touching at their distal ends, and irregularly triangular nearly as wide as broad. The ventral interradial areas are covered with plates similar to those of the dorsal surface except they tend to be smaller, many also carry rugose spinelets.

The jaws are as wide as long or slightly wider, the oral plates are bowed only meeting at their proximal tips. There is one blunt apical papilla flanked on either side by 3–4 long, spine-like, rugose papillae. The adoral shields are approximately triangular and restricted to the proximal sides of oral shields, not separating it from the first lateral arm plate; they often do not meet in the midline proximal to the oral shields. The oral shield is an irregular oblong to a round rhombic shape, sometimes with a distal projection.

The arms are distinctly noded, short, about 3–4 times the disk diameter. The dorsal arm plates are fan shaped and separated. The ventral arm plates are small, pentagonal with a rounded distal edge, sometimes the distal edge is indented. The tentacle pores are small, each is armed with a small pointed tentacle scale. There are 6 rugose arm spines proximally, 4–5 distally. The dorsal most or second dorsal most arm spines are the longest about  $1\frac{1}{2}$  arm segments long, the ventral ones usually less than an arm segment in length.

**REMARKS.** Mortensen (1933a) considered that *O. clavigera* is possibly distinct from *Ophiomitrella cordifera*, pointing out that the difference in shapes of the oral shield and disk spinelets could warrant specific distinction. However, *O. cordifera* appears to be a valid species which can distinguish from *O. clavigera* by the following characters: the shape of oral shield which is rounded slightly irregular in *O. clavigera* but pentagonal to rhombic often with an acute proximal angle in *O. cordifera*, the adoral shields are not separated as in *O. clavigera* but meet in the midline, proximal to the oral shield in *O. cordifera* and the larger size of the granules of the disk in *O. cordifera*.

*O. clavigera* can easily be distinguished from *O. globifera* by the following characters: the plates of the dorsal side are thin not as well developed as in *O. globifera*; the spinelets of *O. clavigera* often have an enlarged rugose tip, those of *O. globifera* are all of one kind, low and rugose, nearly granuliform; the apical and oral papillae of *O. globifera* are shorter and not as rugose as those of *O. clavigera*; the oral shield is more regularly rhombic in *O. globifera* than *O. clavigera* and the tentacles scales of *O. globifera* are large rounded while those of *O. clavigera* are small and spine-like.

**DISTRIBUTION.** *O. clavigera* has been recorded from both sides of the Atlantic; from Nova Scotia north to the Davis Strait and W. Greenland in the western Atlantic with a bathymetric range of 166–1100 m; in the eastern Atlantic it has been recorded from SE. Iceland, off the Faroes, SW. Ireland and the Azores with a bathymetric range of 170–1348 m.

*Ophiomitrella globifera* (Koehler, 1896a)

Fig. 28

*Ophiomitra globifera* Koehler, 1896a: 86–88.

*Ophiomitrella globifera*: Verrill, 1899b: 352; Koehler, 1907: 295.



MATERIAL STUDIED. MNHN: *Travailleur & Talisman* 30th Aout 1883 No. 83 22°57'N: 19°51'W 930 m 2 specimens; *Travailleur & Talisman* 3 Juillet 1883 No. 73 25°39'N: 18°30'W 1475 m 1 specimen.

The disk is pentagonal, up to 9 mm in diameter; covered by large plates each carrying from 1–4 slightly rugose granules. The radial shields are small, slightly less than a quarter of the disk diameter in length, triangular to irregularly rectangular in shape. Their distal edges may be fringed with granules. The ventral interradial areas are covered with plates like those of the dorsal side, some are also armed with granules.

The jaws are as wide as long. There is one large, blunt apical papilla flanked on either side by 3 oral papillae. The oral papillae are slightly flattened and the distalmost papillae may be widened at the free end or in some specimens larger than the others almost opercular. The adoral shields are curved slightly wing-like, with glassy beads embedded in the matrix. The adoral shields do not separate the oral shield from the first lateral arm plate. The oral shields are rounded slightly pentagonal to almost rhombic often there is a distal projection.

The arms are noded. The dorsal arm plates are fan shaped nearly contiguous. The ventral arm plates are pentagonal often with a broad distal edge, the plates on proximal segments are contiguous or nearly so, but separated on distal ones. The tentacle pores are relatively large each is armed with a large flat tentacle scale. There are 7 finely rugose arm spines, with large secondary points on the shaft giving the arm spine a more rugose appearance. The dorsal or second dorsalmost spines is the longest, up to 2 arm segments in length, the ventral arm spines are short often less than an arm segment in length. The arm spines do not form a fan on the proximal arm segments.

REMARKS. *O. globifera* can be distinguished from the other Atlantic species of *Ophiomitrella* by the shape of the disk granules which are much less rugose than those of *O. clavigera*. The papillae of the jaw are more regular in shape, arrangement, and are not long, spine-like like those of *O. clavigera* and *O. cordifera*; adoral shields have glassy tubercles in the plate matrix which appears to be absent in the other species, the ventral arm plates are broader than those of *O. clavigera* and *O. cordifera*.

DISTRIBUTION. *O. globifera* has only been recorded from the eastern Atlantic from the Bay of Biscay, Off NW. Africa and off the Canaries with a bathymetric range of 930–1700 m.

### *Ophiomitrella cordifera* (Koehler, 1896c)

Fig. 28

*Ophiomitra cordifera* Koehler, 1896c: 250–251.

*Ophiomitrella cordifera*: Koehler, 1909: 192.

*Ophiomitrella clavigera*: Mortensen 1927: 186 (non *Ophiomitrella clavigera* Ljungman, 1864).

MATERIAL STUDIED. MNHN: *Princesse Alice* 1st Aout 1895 Stn 618 38°25'15N: 28°52'45W 1143 m SYNTYPE.

The disk is round to pentagonal up to 4 mm disk diameter; covered with large, imbricating plates often armed with low globular granules, many specimens have the granules rubbed off. The radial shields are roughly triangular in shape often contiguous for up to half their length; extending to just about half the radius of the disk. The ventral interradial areas are covered with large plates like those of the dorsal surface, they may also be armed with granule-like spinelets.

The jaws are as wide as long. There is one large pointed apical papilla flanked on either side by 3 flattened, slightly rugose, oral papillae. The adoral shields are rectangular to wing-like just or not quite separating the oral shield from the first lateral arm plate. The oral shield is a rounded rhombic to pentagonal shape; often the proximal angle is acute and produced so that it almost separates the adoral shields.

The arms are slightly noded. The dorsal arm plates are fan shaped and separate. The ventral arm plates are pentagonal, the distal edge is convex but indented in the middle. The ventral arm plates are not contiguous. The tentacle pores are small, each is armed with a small pointed tentacle scale. There are 6–7 slightly rugose arm spines, the shaft of the spines has large secondary points. The dorsal arm spines are the longest nearly two arm segments in length, the ventral arm spines are much shorter. They do not form a fan on proximal arm segments.

REMARKS. *O. cordifera* can be distinguished from other species by the contiguous radial shields, the pentagonal shape of the oral shield often with an acute proximal edge and the small pointed tentacle scale. The similarity between *O. cordifera* and *O. clavigera* has already been commented on under *O. clavigera*.



DISTRIBUTION. This species has been recorded off the Canaries and Azores at depths of 1143–1530 m.

*Ophiothamnus affinis* Ljungman, 1872

Fig. 27

*Ophiothamnus affinis* Ljungman, 1872: 622.

*Ophioleđa minima* Koehler, 1906: 26; 1907a: 292–294; 1914: 111; 1921: 4.

*Ophioplınthaca ocellusa*: Koehler, 1907b: 4; 1909: 194–195.

*Ophiothamnus minima*: Matsumoto, 1917: 123–126.

MATERIAL STUDIED. MNHN: *Travailleur & Talisman*. 1st Aout 1881 No. 39 44°6'N: 9°25'40"W 1220 m (about 20 specimens from a large sample SYNTYPES); *Travailleur & Talisman* 19th Juillet 1882 No. 19 41°32'N: 11°41'W 1350 m SYNTYPES of *Ophioleđa minima*.

The disk is indented interradially and the centre is often depressed, while the area of the radial shields is commonly raised up often swollen, in some specimens the disk distal to the tips of the radial shields bulges out overlying the arm. The disk diameter is up to 5 mm. The disk is covered by small imbricating plates many bearing a simple glassy rod-like spinelet. The radial shields are large extending over half the radius of the disk in length. They are triangular in shape with their distal ends in contact, sometimes they are contiguous or slightly more than half their length. The ventral interradiial areas are also covered with plates some bearing smaller glassy spinelets.

The jaws are as wide as long. There is one large blunt tricuspid or occasionally heart-shaped apical papilla flanked on either side by 3 oral papillae; the proximal papillae are pointed spiniform but the distalmost is large and block-like nearly opercular. The adoral shields are large becoming slightly flared distally, they separate the oral shield from the first lateral arm plate. The oral shield is a rounded triangular shape.

The arms are distinctly noded. The dorsal arm plates are wider than long, approximately triangular in shape and separated from one another. The ventral arm plates are pentagonal with the distal edge slightly indented. The tentacle pores are relatively large, each is armed with a lanceolate tentacle scale which becomes more spiniform on distal pores. The arm spines articulation area does not have a proximal ridge. There are 7–8 simple glassy arm spines of which the second dorsalmost is the longest, up to 3 arm segments long. The arm spines form a fan on the proximal arm segments.

REMARKS. *O. affinis* is similar to *O. vicarius* Lyman, 1869, from the West Indies but differs in the shape of the apical papilla which is simple blunt or slightly pointed in *O. affinis* as opposed to heart shaped in *O. vicarius*, though the occasional occurrence of heart shaped apical papillae in *O. affinis* throws doubt on the validity of this character, the degree to which the disk is constricted interradially, which is very pronounced in most specimens of *O. affinis* but not noticeably so in *O. vicarius*; and the number of arm spines, 7–8 in *O. affinis* but as many as 10–12 *O. vicarius*.

DISTRIBUTION. *O. affinis* has been recorded from both sides of the North Atlantic; in the western Atlantic from off Florida in 229–491 m and in the eastern Atlantic from the Bay of Biscay, off the Canaries and from the Josephina Bank with a bathymetric range of 1425–1935 m.

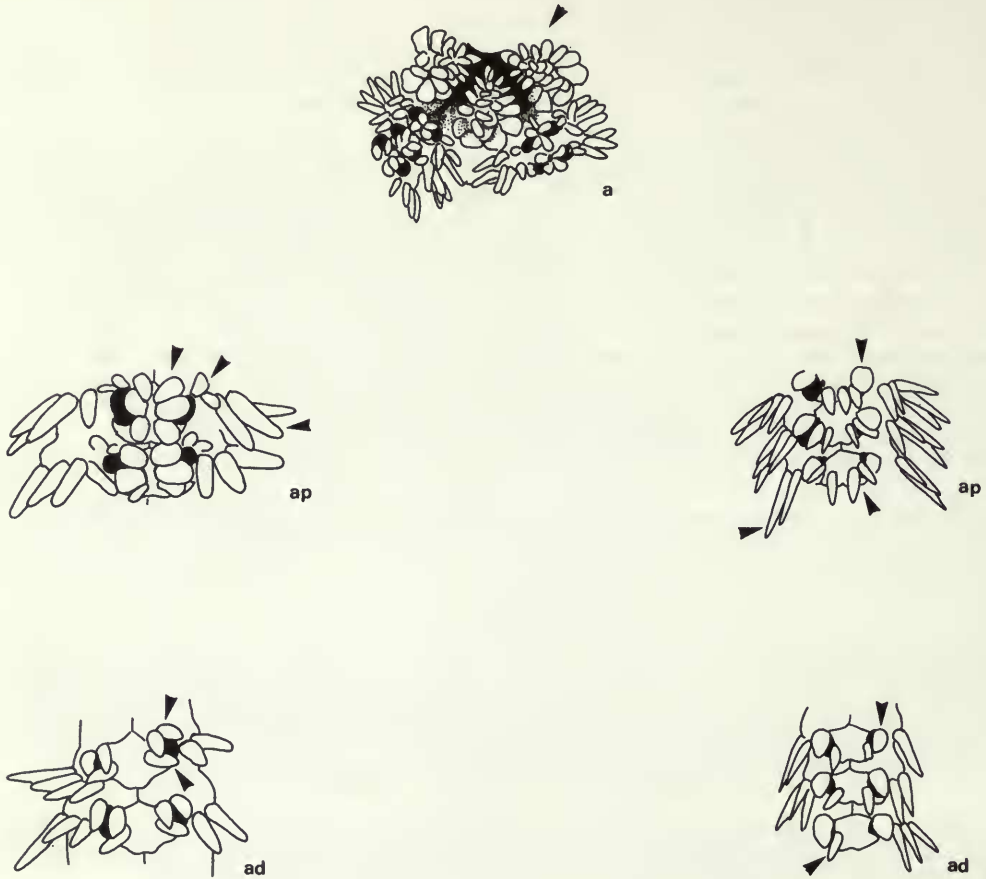
OPHIOHELINAE (Perrier, 1891 amended)

DIAGNOSIS. A subfamily of the Ophiacanthidae with simple arm spine articulation surfaces on the lateral arm plates, not forming a comma-shaped surface; disk delicate, sack-like covered with small thin semitransparent scales; radial shields absent or internally concealed; jaws as broad as long often with numerous flattened distally projecting papillae arranged in two or more rows covering the surface of the jaw; arms noded, often standing vertically around the disk position found in preserved specimens; tentacle pores large open with up to five tentacle scales; arm spines often numerous varying in length.

TYPE GENUS. *Ophiomyces* Lyman, 1869 with type species *O. frutescens* Lyman, 1869.

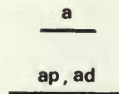
REMARKS. The genera included are: *Ophiohelus* Lyman, 1878; *Ophiomyces* Lyman, 1869; *Ophiothauma* H. L. Clark, 1938 and *Ophiotholia* Lyman, 1880. Verrill (1899) proposed that *Ophiomyces* and *Ophiotholia* be segregated as a separate family and Fell (1960) suggested that if Verrill's proposal is valid then *Ophiothauma* should be included. *Ophiohelus* is considered to be closely allied to these three genera. It is not possible at present to assess the taxonomic weight of the character of the arm spine articulation surface on the lateral arm plates, whether of familial or

## OPHIACANTHIDAE : OPHIOHELINAE



**Ophiomyces grandis**

**Ophiomyces frutectosus**



**Fig. 31** Key to the Ophiacanthidae: Ophiohelinae. *Ophiomyces*: (a) ventral view of *Ophiomyces*; (ap) detail of ventral side of the proximal arm segments showing the arrangement of tentacle scales; (ad) detail of the ventral side of the distal arm segments to show the tentacle scales. Bar scales = 1 mm.

subfamilial worth as only a few species have yet been examined. Most Ophiacanthids so far examined possess a comma shaped surface except for *Ophiomyces*, the possession of similar articulation surfaces in *Ophiohelus*, *Ophiothauma* and *Ophiotholia* is inferred pending future study, so an absence of this form of socket would support Verrill's proposal.

*Ophiomyces fructosus* Lyman, 1869

Fig. 31

*Ophiomyces fructosus* Lyman, 1869: 343; 1882: 243; Ljungman, 1871: 615–657; Mortensen, 1927: 185; Tommasi, 1970: 18–19.

MATERIAL STUDIED. **BMNH**: *Explorer* 24°53'N: 80°04'W 365–375 m 5 specimens.

The disk is round, sack-like, often raised up; diameter up to 9 mm; covered with thin semi-transparent scales often carrying a simple rod. The radial shields are not visible, probably absent. The ventral interradial areas are covered by scales like those of the dorsal surface but the rod-like spinelets are usually smaller.

The jaws are as wide as long. The surface of the oral plates adoral and oral shields is obscured by superficial, wide, flat papillae. There is one flat, broad, apical papillae flanked by two rows of each of about 5 papillae flanking on each side, the row situated on the surface of the oral plates are considered to be supplementary. The proximal papillae of each series are flat and slightly spiniform but the distal ones become wider especially the free edge with the distalmost papillae being very large, almost triangular. The adoral shields are small wing-like almost separating the oral shield from the first lateral arm plate. The oral shield is small, arrow shaped. These shields are obscured by the supplementary papillae and by papillae arising on the shields themselves.

The arms are flattened. The lateral arm plates on the proximal part of the arm are slightly enlarged. The dorsal arm plates are fan shaped, much wider than long and separated from one another. The ventral arm plates are longer than wide with the lateral edges distinctly convex and the distal edge indented, they are contiguous on proximal segments, separated on distal ones. The tentacle pores are large, the proximal ones are armed with 3 flat, elongated, tentacle scales, one on the lateral arm plate the other two arising on the ventral arm plate. The first may be difficult to distinguish from the ventral arm spines but may be recognised because it usually lies between the preceding arm spine row and the row of the arm segment with the pore. On distal tentacle pores there are only two tentacle scales, a large rounded one arising on the lateral arm plate and a smaller more spine-like one on the ventral arm plate. There are 8–10 arm spines, the dorsalmost 3–4 are small, thin and spine-like the remaining gradually become larger towards the ventral side with the largest spines being in the middle of the series. These larger spines are slightly flattened and on proximal joints may have blunt tips. On proximal joints the dorsal arm spines from one side of the arm form a continuous series with those from the other, but this cannot be called a fan in the sense used in other genera of the Ophiacanthidae.

REMARKS. *Ophiomyces fructosus* may be distinguished from the second N. Atlantic species, *O. grandis*, by the arrangement of the tentacle scales on the proximal pores; *O. grandis* having up to 5 tentacle scales, two on the lateral arm plate and three on the ventral arm plate. Distally *O. grandis* has three spine-like scales, two on the lateral arm plates and one on the ventral arm plates. Near the tip of the arm *O. grandis* may have just one large rounded scale on the ventral arm plate.

DISTRIBUTION. This species has been recorded primarily from the Caribbean and off Florida but Ljungman (1871) records it from the Josephina Bank, W. of Portugal in 210–410 m. Bathymetric records suggest that it is a bathyal species with its lower limit in the upper abyssal zone.

*Ophiomyces grandis* Lyman, 1878

Fig. 31

*Ophiomyces grandis* Lyman, 1878: 383–385; 1882: 241–242; Koehler, 1907: 295; Mortensen, 1927: 185; Cherbonnier, 1966: 846; Cherbonnier, 1970: 346–348; Cherbonnier & Sibuet, 1972: 1366; Gage *et al.*, 1983: 288–289.

*Ophiomyces peresi* Reys, 1961: 154–155.

MATERIAL STUDIED. **BMNH**: HMS *Challenger* Tristan d'Acunha 1800 m HOLOTYPE.

**SMBA**: RRS *Challenger* II: Stn 62 57°28'N: 11°00'W 610 m 2 specimens.

**IOS**: *Discovery* Investigations: Stn 7857 3 36°44'N: 14°18'W 277–271 m 1 specimen.



The disk is round, sack-like and often raised up, diameter up to 9 mm; covered with small semi-transparent scales, many of them are armed with large simple rods. The radial shields are not visible, probably absent. The ventral interradiar areas are similar to the dorsal side but the rods are not as long.

The jaw is as wide as long. The surface of the jaw, adoral and oral shields are obscured by papillae. There is one apical oral papilla flanked on each side by two rows of papillae. The series of oral papillae line the free edge of the jaw while the supplementary papillae lie on the surface. There are 5–6 oral papillae and 5 or more supplementary papillae. The proximal papillae of both rows are spine-like but distally they become flatter and wider with the distalmost papillae of each series being nearly triangular. The adoral shields are wing shaped, with very angular lateral projections and separate or just fail to separate the oral shield from the first lateral arm plate. The oral shield is quite large and arrow shaped. These plates are usually obscured by papillae.

The arms are flattened. The dorsal arm plates are wider than long and separated from one another. The ventral arm plates are longer than wide with concave lateral edges and an indented distal edge, they are almost contiguous proximally but widely separated distally. The tentacle pores are large and open on proximal arm segments. These proximal tentacle pores are armed with 5 blunt club shaped tentacle scales, but on distal segments there are usually only three tentacle scales, two on the lateral arm plate and one on the ventral arm plate; often one of the tentacle scale is larger and more rounded than the others. Near the tip of the arm there is usually only one rounded tentacle scale. There are 9 arm spines proximally. The dorsalmost 3–4 are small, thin with subsequent spines gradually becoming larger, the largest being those in the middle of the series. These spines are flattened and pointed.

**REMARKS.** A comparison of *O. grandis* with the other N. Atlantic species *O. frutescens* is dealt with under that species.

**DISTRIBUTION.** This species has been recorded from the Rockall Trough south to Gibraltar, with a bathymetric range of 230–800 m, in the North Atlantic. It has also been recorded from Tristan d'Acunha in 1800 m, the type locality.

#### OPHIACTIDAE Matsumoto, 1915

This family is characterised by the disk covered with plates often carrying spinelets or granules which do not conceal them, except in *Ophiopholis* where the granules obscure the plates; radial shields usually conspicuous; one apical papilla flanked with rounded oral papillae often separated from it by a diastema and not forming a contiguous series with it, except in *Histampica*; the second oral tentacle pore opening within the oral slit; arm spines short, pointed and erect, not appressed to the side of the arm.

#### *Ophiactis abyssicola* (M. Sars 1861)

Fig. 32

*Amphiura abyssicola* M. Sars, 1861: 18.

*Ophiocnida abyssicola*: Lyman, 1865: 12.

*Ophiactis abyssicola*: Ljungman, 1867b: 324; Lütken, 1872: 98; Lyman, 1882: 122; Hoyle, 1884: 710, 715, 718; Bell, 1892: 123; Koehler, 1898: 46; Grieg, 1903: 29; Koehler, 1909: 169; Mortensen, 1913: 356; Farran, 1913: 35; Grieg, 1921: 36; H. L. Clark, 1923: 334; Koehler, 1924: 293; Mortensen, 1927: 202; 1933a: 47–50; John & Clark, 1954: 154; Cherbonnier & Sibuet, 1972: 1370; Gage *et al.*, 1983: 292.

*Ophiactis poa* Lyman, 1882: 119.

*Ophiactis echinata* Koehler, 1898: 48; Mortensen, 1927: 199; Cherbonnier & Sibuet, 1972: 1370.

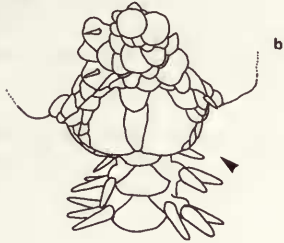
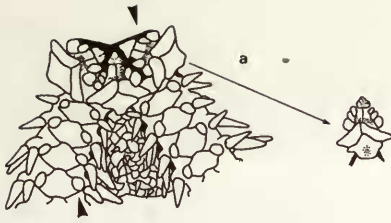
*Ophiactis corallicola* Koehler, 1896a: 75; 1907: 272; 1909: 170.

**MATERIAL STUDIED.** **COB:** BIOGAS Stn 1: DS15 2246 m 16 specimens; DS16 2325 m 34 specimens; DS17 2103 m 40 specimens; DS18 2138 m 30 specimens; DS32 2138 m 1 specimen; DS35 2226 m 1 specimen; DS61 2250 m 2 specimens; DS63 2126 m 2 specimens; DS65 2360 m 4 specimens; CV08 2180 m 2 specimens; CV09 2119 m 27 specimens; CV10 2108 m 29 specimens; CV20 2282 m 2 specimens; CV23 2034 m 6 specimens; CV24 2025 m 9 specimens; CV25 1985 m 2 specimens; CP01 2245 m 25 specimens; CP02 2177 m 22 specimens; CV39 2350 m 16 specimens; CP08 2177 m 13 specimens; CP26 2115 m 6 specimens; CP27 1920 m 31 specimens.

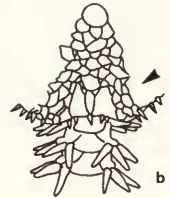
BIOGAS Stn 2: DS60 3742 m 2 specimens; DS66 3480 m 1 specimen; CV41 3800 m 1 specimen; CP09 2171 m 50 specimens; CP28 3380 m 2 specimens.

BIOGAS Stn 4: CV35 4721 m 1 specimen.

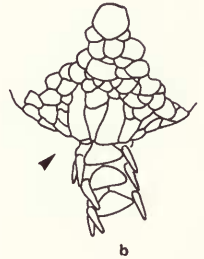
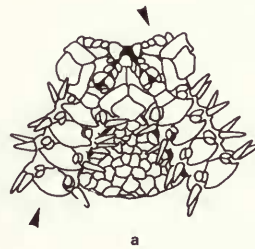
OPIACTIDAE



*Ophiactis abyssicola*

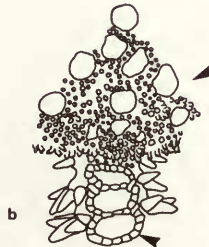
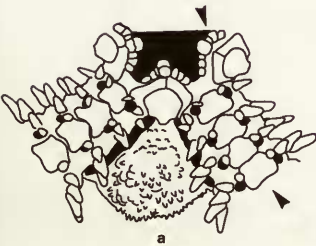


*Ophiactis balli*

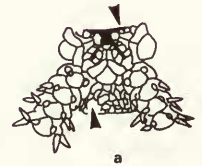


*Histampica duplicata*

a, b



*Ophiopholis aculeata* \*



*Ophiopus arcticus* \*

Fig. 32 Key to the Ophiactidae. *Ophiactis*, *Histampica*, *Ophiopholis* and *Ophiopus*: (a) ventral; (b) dorsal view of disk. Bar scales = 1 mm, \*—not described in text.

BIOGAS Stn 6: DS52 2006 m 1 specimen; DS70 2150 m 1 specimen; CV16 1909 m 18 specimens; CV32 1895 m 2 specimens; CP07 2170 m 89 specimens; CP23 1980 m 15 specimens; CP25 1894 m 1 specimen.

BIOGAS Stn HZ: DS04 1100 m 6 specimens; DS33 2338 m 28 specimens; CM01 1100 m 1 specimen; CV06 2200 m 5 specimens; CW03 2160 m 8 specimens; CV11 2141 m 7 specimens; CV22 1331 m 68 specimens.

IOS: *Discovery* Investigations Stn 8511/2 41°49'N: 11°06'W 2574–2585 m 1 specimen; Stn 8967 31°25'9"N: 10°53'7"W–31°26'3"N: 10°50'8'W 11 specimens; Stn 8970 31°30'4"N: 11°4'4'W–31°30'0"N: 11°3'8'W 5 specimens; Stn 9029 32°14'3'N: 11°28'W–32°14'1'N: 11°2'5'W 1886–1835 m 1 specimen; Stn 9042 42°15'0'N: 11°22'0'W 1662–1541 m 20 specimens; Stn 9753/4 50°54'9'N: 12°12'W–50°56'5'N: 12°14'8'W 1942–1947 m 1 specimen; Stn 9753/7 60°54'5'N: 12°10'9'W–50°59'8'N: 12°11'4'W 1942 m 3 specimens; Stn 9754/3 51°8'4'N: 12°1'5'W–51°9'5'N: 12°1'8'W 1484 m 2 specimens.

The disk may be round or indented; covered by large plates amongst which the centrodorsal plate and usually the primary plates are distinct; disk diameter up to 9 mm. There are often conical spinelets on both the dorsal and the ventral interradial plates, however, they may be absent from one or other side or even completely missing. The radial shields are large, longer than broad, sometimes contiguous but usually separated by a single row of plates. The plates of the ventral interradial areas are not as coarse as those on the dorsal surface.

There is a tricuspid or heart shaped apical papilla flanked on each side by two distal oral papillae, which arise on the adoral shields occasionally the more distal one is divided making it appear as two papillae. The adoral shields are large, longer than broad, not separating the oral shield from the first lateral arm plate. The oral shield is lozenge shaped or rhombic.

The dorsal arm plates are fan shaped and contiguous at least proximally. The ventral arm plates are pentagonal with a rounded distal edge and contiguous at least on proximal arm segments. There is one round tentacle scale on each tentacle pore. There are 4 conical arm spines on the proximal arm segments 3 further out.

REMARKS. *Ophiactis abyssicola* is a variable species, a fact which has misled authors in the past. Mortensen (1933a) concluded that the characters of the disk are subject to a number of variations, especially occurrence of spines, differences in scaling, but that features of the oral frame are sufficiently constant to easily identify this species.

DISTRIBUTION. *O. abyssicola* has been recorded from the Davis Strait, off Iceland, the Faeroes and Norway south to southern Africa, with a bathymetric range of 125–4721 m.

### *Ophiactis balli* (Thompson, 1840)

Fig. 32

*Ophiocoma balli* Thompson, 1840: 99; Forbes, 1840: 35; Thompson, 1856: 437.

*Ophiocoma goodsira* Forbes, 1840: 57.

*Ophiactis balli*: Lütken, 1859: 126; Lyman, 1882: 121; Hoyle, 1884: 718; 1885: 143.

*Ophiolepis ballii*: Müller & Troschel, 1842: 97.

*Ophiolepis goodsira*: Müller & Troschel, 1842: 97.

*Ophiopholis ballii*: Gray, 1848: 25.

*Ophiopholis goodsira*: Gray, 1848: 25.

*Amphiura balli*: Sars, 1859: 42; 1861: 17; Norman, 1865: 109.

*Ophiocnida balli*: Lyman, 1865: 12.

*Ophiactis balli*: Koehler, 1896a: 77; Bell, 1892: 123–124; Grieg, 1903: 29; Koehler, 1909: 169; Süßbach & Brecker, 1911: 252; Farran, 1913: 37; Koehler, 1921: 83; 1924: 292; Mortensen, 1925: 181; 1927: 200; 1933a: 51–52; Gage *et al.*, 1983: 292.

MATERIAL STUDIED. COB: BIOGAS Stn HZ D01 400 m 2 specimens.

BMNH: D'Arcy Thompson Coll. Moray Firth c.25 specimens.

The disk is round, covered with small plates amongst which the primary plates are inconspicuous; disk diameter up to 5 mm. The radial shields are small and longer than broad. The ventral interradial area has smaller plates than the dorsal surface. There are often small spinelets on the ventral side on the edge of the disk, and occasionally on the dorsal side.

There is a pointed or heart shaped apical papilla with one pointed oral papilla on each side usually arising on the oral plates. The adoral shields are large, flared distally and often not meeting proximally. The oral shield is rounded triangular often with the lateral edges slightly concave.



**Table 2** Comparison of North Atlantic Ophiactidae species.  $l$  = length,  $b$  = breadth,  $dr$  = disk radius, A.P. = apical papillae, O.P. = oral papillae

SPECIES	DISK PLATING	RADIAL SHIELDS	MOUTH PAPILLAE	ORAL SHIELD SHAPE	GENITAL SLITS	DORSAL ARM PLATE	ARM SPINE NO
<i>Ophiactis abyssicola</i> (Fig. 32)	large plates often with spinelets	large, $l \geq \frac{1}{2} dr$ ; $l > b$	1 A.P., 2/3 O.P. O.P. separated	rhombic $l < b$	present	fan-shaped contiguous	4-3
<i>Ophiactis balli</i> (Fig. 32)	small plates spinelets usually confined to disk edge	small $l \leq \frac{1}{4} dr$ ; large $l \geq \frac{1}{2} dr$ ; $l > b$	1 A.P., 1 O.P. O.P. separated	rounded triangular $l = b$	present	rounded contiguous	5-3
<i>Histampica duplicata</i> (Fig. 32)	large plates	small $l = \frac{1}{4} dr$ ; $l > b$	1 A.P., 5-6 O.P. O.P. contiguous	pointed triangular $l > b$	present	fan-shaped contiguous	3
<i>Ophiopholis aculeata</i> (Fig. 32)	only CD & PP visible rest covered with granules spinelets	not usually visible	1 A.P., 3 O.P. O.P. contiguous	oval $l < b$	present	oblong sur-rounded by small plates	4-3
<i>Ophiopus arcticus</i> (Fig. 32)	large plates	small $l = \frac{1}{4} dr$ ; $l \geq b$	1 A.P., 2 O.P. O.P. contiguous	pointed triangular $l > b$	absent	fan-shaped contiguous	7-6

The dorsal arm plates are rounded triangular to fan shaped and contiguous. The ventral arm plates are pentagonal to almost rectangular, the distal edge may be slightly concave. The tentacle pores have one broad tentacle scale. There are 5 conical arm spines proximally, the middle ones usually the largest; distally there are only 4.

REMARKS. *Ophiactis balli* differs from *O. abyssicola* in the following characters: it only has one distal oral papilla, which arises on the oral plate, it has fewer arm spines and the shape of the ventral arm plates which are almost square compared to the distinctly pentagonal plates of *O. abyssicola*.

DISTRIBUTION. *Ophiactis balli* is more commonly found in shallower depths (between 60–400). It is confined to the eastern Atlantic.

*Histampica duplicata* (Lyman, 1875)

Fig. 32

*Amphiura duplicata* Lyman, 1875: 19; 1879: 31; 1882: 136; 1883: 251; Koehler, 1896: 74; 1898: 49.

*Ophiactis duplicata*: Lütken & Mortensen, 1899: 142–143; Koehler, 1909: 171; 1914: 40.

*Amphiactis duplicata*: Matsumoto, 1915: 66–67; 1917: 146–147; Mortensen, 1927: 198.

*Histampica duplicata*: A. M. Clark, 1970: 73–74.

MATERIAL STUDIED. **COB**: BIOGAS Stn 1: DS15 2246 m 5 specimens; DS17 2103 m 6 specimens; CV09 2119 m 1 specimen; CV10 2108 m 4 specimens; CV20 2282 m 1 specimen; CP01 2245 m 8 specimens; CP02 2177 m 4 specimens; CV39 2350 m 1 specimen; CP27 1920 m 2 specimens. BIOGAS Stn 6: DS25 2096 m 1 specimen; DS26 2076 m 1 specimen; CP07 2170 m 72 specimens. BIOGAS Stn HZ: CW03 2160 m 1 specimen.

**IOS**: *Discovery* Investigations Stn 9042 42°15'N: 11°22'0'W 1662–1541 m 4 specimens.

The disk is round; covered with many large plates amongst which the centrodorsal and usually the primary plates are distinct, often these plates have a knob in the centre; disk diameter up to 9 mm. The radial shields are about twice as long as broad, separated by a wedge of plates, nearly half the disk radius in length. The ventral interradial areas covered by plates slightly smaller than those of the dorsal side.

There is one large tricuspid papilla flanked on each side by 3–5 rounded oral papillae. The first oral tentacle scale which usually lies below these papillae, often becomes superficial and joins the oral papillae series. The adoral shields are large, becoming slightly flared distally, separating the oral shield from the first lateral arm plates. The oral shield is triangular to rounded pentagonal in shape with an obtuse proximal angle and a rounded distal edge.

The arms are relatively long and capable of vertical coiling. The dorsal arm plates are fan shaped, contiguous at least on proximal segments. The ventral arm plates are axe shaped; with an obtuse proximal angle, indented lateral edges and a convex distal edge, and are contiguous, at least proximally. The tentacle pores are large and armed with two rounded or slightly elliptical tentacle scales. There are 3 slightly flattened pointed conical arm spines, of which the middle one is the largest.

REMARKS. *H. duplicata* can be recognised from other ophiactids by the arrangement of the oral papillae; the form of the ventral arm plates, the number of tentacle scales, the scaling of the disk and the number of arm spines.

DISTRIBUTION. *H. duplicata* is a widespread species recorded from the West Indies, Bay of Biscay to off North Africa, and from the East Pacific off Colombia and Ecuador with a bathymetric range of 125–2870 m.

AMPHIURIDAE Ljungman, 1867

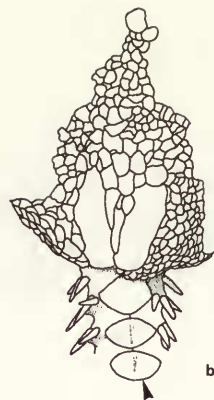
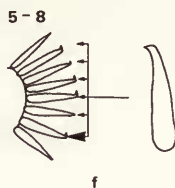
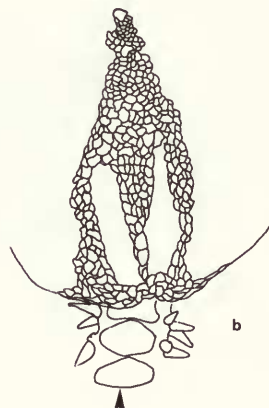
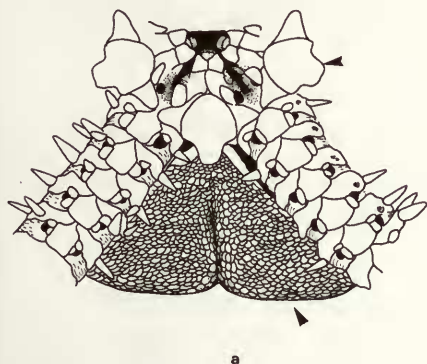
This family is characterised by the paired infradental papillae at the apex of the jaw. The disk is usually scaled, the arms are very long and the arm spines are short and erect. There is a single series of square or in the case of *Amphioplus* sometimes tricuspid teeth.

The disk in this family is delicate and prone to damage and it is common to find deep sea specimens without their disks. However, it should be possible to identify such specimens to genus and often to species from the remaining characters.

The genera of this family are characterised chiefly by the arrangement and number of oral papillae. A. M. Clark (1970), reviewing the genera using these characters, proposed a linear

## AMPHIURIDAE

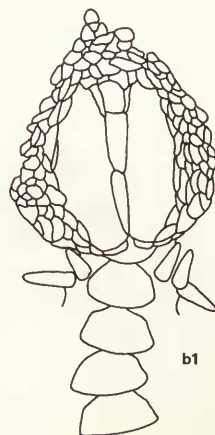
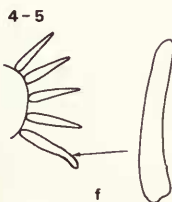
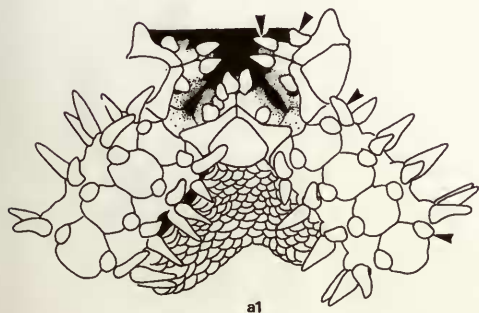
## AMPHIURA

*A. otteri**A. tritonis*


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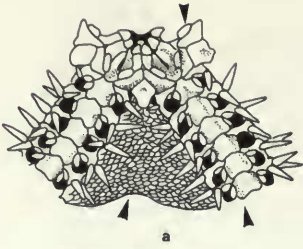
 a, b

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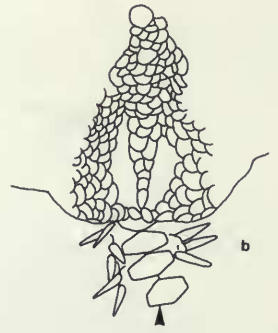
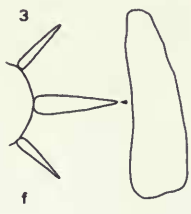
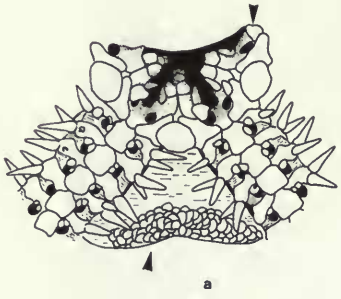
 a1, b1
*A. grandisquama*

**Fig. 33** Key to the Amphiuridae. *Amphiura*: (a) ventral; (b) dorsal views of disk; (f) diagrammatic representation of arm spine number and position of modified arm spines. The number represents the number of proximal arm spines. Modified arm spines are drawn enlarged and their position on the lateral arm plate indicated by an arrowed line. Bar scales = 1 mm.



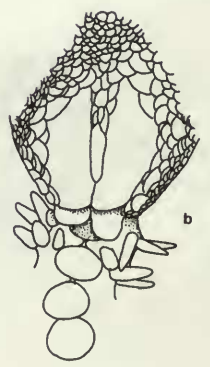
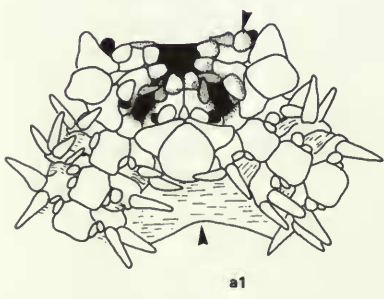


**A. chiajei**



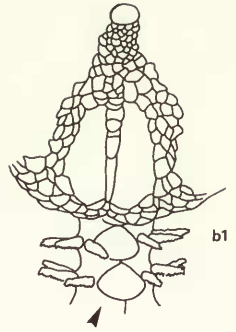
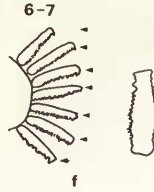
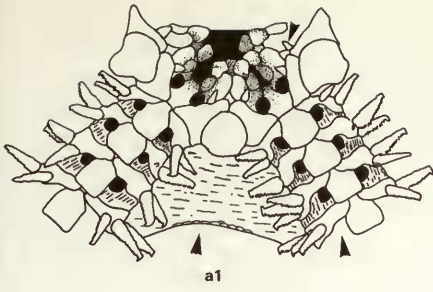
**A. richardi**

a, b  
a1, b1

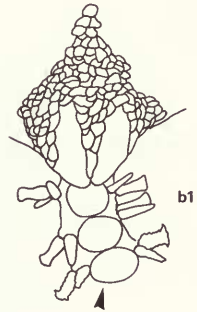
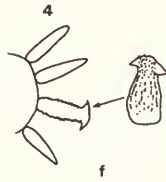
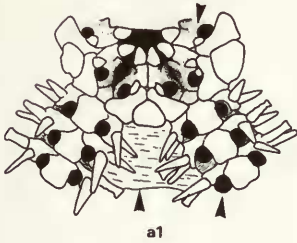


**A. griegi**

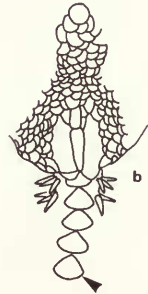
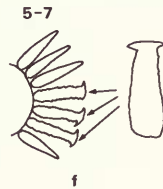
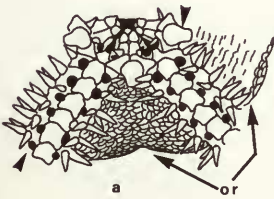
**Fig. 34** Amphiridae. *Amphiura*. Captions as in Fig. 33.



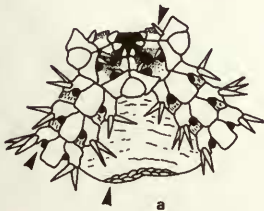
**A. fragilis**



**A. borealis**



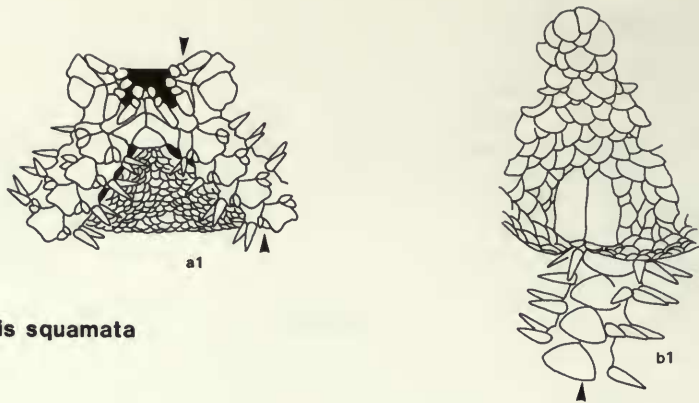
**A. filiformis**



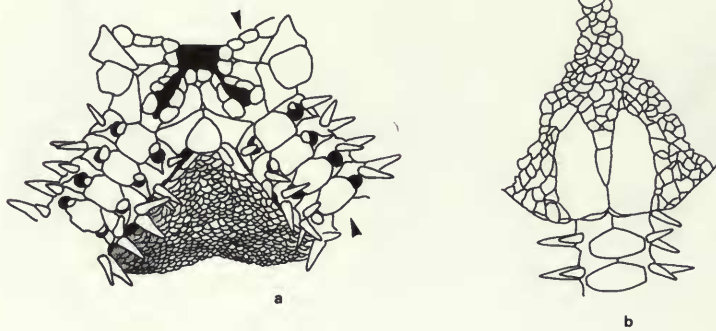
**A. abyssorum**

a, b  
a1, b1

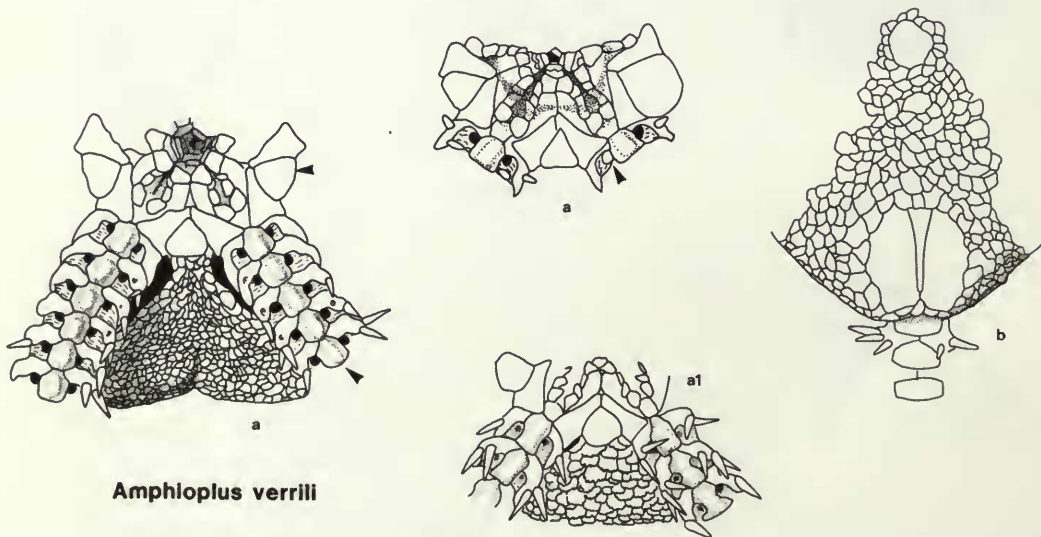
Fig. 35 Amphiuroidae. *Amphiura*. Captions as in Fig. 33.



**Amphipholis squamata**



**Amphioplus daleus**



**Amphioplus verrilli**

**Fig. 36** Amphiuridae. *Amphipholis* and *Amphioplus*. Captions as in Fig. 33.



formula to express the occurrence of the oral papillae. The formula is given below and her conclusions where applicable are followed here.

1. The three main areas of the jaw, the apex below the dental plate, the side of the oral plate and the edge of the adoral shields, are delimited from one another by commas.
2. Each papilla arising entirely from a single area is represented by the letter m.
3. In cases where a papilla arises on two adjacent areas the m is split into 2n's with a comma between them and a linking bar above them.
4. A significant gap between papillae is indicated by an o.
5. The presence or absence of the first oral tentacle scale is denoted by + or -t. In most genera the oral tentacle scales arise deep within the mouth slit and not on the same level as the other papillae. However, in *Amphioplus* there is a more or less superficial second papilla next to the infradental papilla which is homologous with the first oral tentacle scale. This relationship is indicated by equating it with the first m of the oral plate is the second area.
6. If a papilla is particularly enlarged it may be shown by the use of capitals i.e. M or N, N.

The formulae together with a brief diagnosis is given of the genera found in the abyssal North Atlantic.

*Amphiura* Forbes 1843: m, o m, o+t. A single distal oral papillae, very occasionally two as in *A. filiformis* and *A. otteri*, separated from the infradental papillae by a space or diastema. The first oral tentacle scale arises deeper within the mouth slit and therefore not contiguous with the infradental papillae. The radial shields are usually separated or contiguous only distally. The ventral arm plates are flat or at most weakly arched.

Ten species have been recorded from the bathyal and abyssal North Atlantic: *A. abyssorum* Norman, 1876; *A. borealis* (G. O. Sars, 1871); *A. chiajei* Forbes, 1843; *A. filiformis* (O. F. Muller, 1776); *A. fragilis* Verrill, 1885; *A. grandisquama* Lyman, 1869; *A. greigi* Mortensen, 1920; *A. otteri* Ljungman, 1871; *A. richardi* Koehler, 1896; *A. tritonis* Hoyle, 1884.

The key to these species is given in figs. 33-36.

*Amphiopholis* Ljungman, 1867: m, m N, N-t. The two oral papillae contiguous with the infradental papillae. The distal most papilla is enlarged and block-like. The radial shields are usually widely contiguous. The ventral arm plates are usually flat. Only one species has been recorded below 1000 m.

*A. squamata* (D. Chiaje, 1829) page 91.

*Amphioplus* Verrill, 1889a subgenus *Unioplus* Fell, 1962: m (m=t) m, M; m, (m=t) m, N, N; or m, om, N, N(+t). The oral papillae form a continuous series, there are no significant gaps between the papillae. The second oral papilla is in fact the superficial first oral tentacle scale. The ventral arm plates are flat or arched. There is one rounded tentacle scale on each tentacle pore. Only two species have so far been recorded in the deep N. Atlantic; *A. daleus* (Lyman, 1879) page 92. *A. verrilli* (Lyman, 1879) page 92.

### *Amphiura tritonis* Hoyle, 1884

Fig. 33

*Amphiura bellis* var. *tritonis* Hoyle, 1884: 716; Mortensen, 1927: 213; Nobre, 1931: 85.

*Amphiura bellis*: Koehler, 1907: 277. (non *Amphiura bellis* Lyman, 1879).

MATERIAL STUDIED. BMNH: *Triton* Faeroe Channel, 930 m HOLOTYPE.

The disk diameter is up to 12 mm, pentagonal, indented interradially. The disk plates are small, imbricating, the centrodorsal plate is distinct but the primary plates are inconspicuous. The radial shields are 3-4 times as long as broad, extending to just over half the radius of the disk. The ventral interradiation areas are covered with small scales.

The infradental papillae are block-like and contiguous. The distal oral papillae are large and scale-like. The adoral shields are wing-like but do not separate the oral shield from the first lateral arm plate. The oral shield is triangular but with a very prominent distal lobe giving the plate an arrow shape.

The dorsal arm plates are roundly hexagonal and contiguous proximally. The ventral arm plates are distinctly pentagonal. The tentacle pores are large with two large tentacle scales. There are three or four conical pointed arm spines.

REMARKS. Although both Hoyle (1884) and Mortensen (1927) consider that this species might be conspecific with *Amphiura bellis* Lyman, however, the shape of the oral shield and the distal oral papillae are sufficient to warrant specific distinction for *A. tritonis*. The oral shield of *A. bellis* is slightly rounded triangular while in *A. tritonis* it is distinctly arrowhead-shaped and this disparity cannot be attributed to differences in size. Koehler's (1907) description of *A. bellis* closely resembles *A. tritonis*, particularly in the well developed distal lobe to the oral shield.

DISTRIBUTION. This is a rare species with only three known records all in the Eastern Atlantic the Faeroe Channel, 930 m (Hoyle, 1884), Bay of Biscay 627 m and 1290 m (Koehler, 1907: *Travailleur & Talisman* under the name of *A. bellis*).

*Amphiura otteri* Ljungman, 1872

Fig. 33

*Amphiura otteri* Ljungman, 1872: 631; Lütken, 1872: 98–101; Lyman, 1878: 32; 1882: 128; 1883: 252; Verrill, 1885b: 548; Koehler, 1907: 302; 1914: 61; Mortensen, 1927: 210; Nobre, 1931: 85; Gage *et al.*, 1983: 292–293.

*Amphiura grandis* Koehler, 1896c: 246; 1907: 277; 1909: 175–177; Mortensen, 1927: 210.

*Amphiura palmeri* Koehler, 1907: 279 (part); Mortensen, 1927: 209; 1933a: 59–61 (non *A. palmeri* Lyman, 1875).

MATERIAL STUDIED. **BMNH:** HMS *Challenger* Stn 45, 32°34'N: 72°10'N, 2268 m 1 specimen; HMS *Challenger* Stn 50, off Nova Scotia, 2286 m 1 specimen; HMS *Challenger* Stn 76, off the Azores, 1646 m 1 specimen; US Fisheries Commission. Stn 2042, off Martha's Vineyard, 1799 m 1 specimen; *Dana* Stn 2346 Davis Strait 450 m 1 specimen; *Manahine* Stn 5, SW Ireland, 729–819 m 2 specimens.

**MNHN:** *Talisman* drag. 101, 16°38'N: 20°44'W, 3200 m. 16 specimens.

**IOS:** *Discovery* Investigations: Stn 8521/6 20°48'N: 18°53'W 3070–3064 m.

**COB:** BIOGAS Stn 1: DS65 2360 m 1 specimen; CP01 2245 m 2 specimens. BIOGAS Stn 6: DS6 2090 m 6 specimens; DS26 W 2076 m 13 specimens; DS49 1845 m 6 specimens; DS50 2124 m 6 specimens; DS52 2006 m 18 specimens; DS86 1950 m 9 specimens; DS87 1913 m 14 specimens; DS88 1894 m. BIOGAS Stn HZ: DS34 1031 m 1 specimen.

The disk is pentagonal, indented interradially and covered by small scales amongst which the centrodorsal and primary plates are conspicuous, disk diameter up to 8–10 mm. The radial shields are equal to or less than half the disk radius, about twice as long as broad and contiguous only distally. The ventral interradiial areas are covered with small scales.

The infradental papillae are block-like often contiguous. The first oral tentacle scale is distinctly spine-like occurring within the mouth slit. The distal oral papillae are also spine-like and arise on the adoral shields, in some specimens they may be absent. The oral shield may be rounded and triangular or distally lobed and like a blunt flattened arrow head.

The dorsal arm plates are hexagonal and the proximal ones are almost contiguous. The ventral arm plates are pentagonal, contiguous becoming square distally. The tentacle pores are large with two small tentacles although in some specimens one or both scales may be missing on some of the pores. There are 5–8 pointed arm spines; the second ventralmost spine and some of those dorsal to it may have a small distally directed terminal hook.

REMARKS. Mortensen (1927) remarked that *A. otteri*, *A. grandis* and *A. bellis* var. *tritonis* are not easily distinguished. In his key he differentiates them on the number of arm spines and suggested that *A. grandis* could be separated from *A. otteri* by its ridged proximal ventral arm plates and by a lower number of arm spines. However, a study of specimens of *A. grandis* identified by Koehler shows that the ridged ventral arm plates do not appear to be constant feature and that differences in arm spine number are within the normal range found in *A. otteri*. In the absence of any other constant characters it may be concluded that these two species are conspecific. Mortensen's (1933a) confusion over the identity of the *Ingolf* specimens from Iceland can be attributed to the form of the second arm spine. Mortensen described it as having a hooked tip and identified his specimens as *A. palmeri*, type locality: Key Biscayne, Florida because that species has a prominent hook on the second arm spine. He evidently forgot that *A. otteri* also has a hooked tip to this arm spine. The arm spines of *A. palmeri* are very different from Mortensen's specimen;



they are thick with a very distinct hook, the arm spines of *A. otteri* are slender with only a small hook, like those of the *Ingolfs* specimens.

The specimens identified by Koehler (1907) as *A. palmeri* proved on re-examination to be wrongly identified, some of them are *A. filiformis* and some *A. grandis*. *A. palmeri* has only been found in the tropical western Atlantic in comparatively shallow water.

**DISTRIBUTION.** *A. otteri* has been recorded from both sides of the North Atlantic. In the west from the West Indies 325–1036 m and as far north as the Labrador basin 198–2888 m; in the east Atlantic it has been recorded from Southern Iceland, Rockall Trough, south to the Cape Verde Islands with a bathymetric range of 729–3200 m.

*Amphiura grandisquama* Lyman, 1869

Fig. 33

*Amphiura grandisquama* Lyman, 1869: 334; Verrill, 1899a: 26; Koehler, 1907: 301; Mortensen, 1927: 211; Madsen, 1970: 177.

*Amphiura josephinae* Ljungman, 1871: 631.

*Amphiura iris* Lyman, 1879: 23; 1882: 132.

*Amphiura longispina* Koehler, 1896a: 74–75; 1897b: 211; 1898: 52; 1907: 279.

*Amphiura grandisquama guineensis* Mortensen, 1936: 269.

*Amphiura apicula* Cherbonnier, 1957: 200.

**MATERIAL STUDIED.** MCZ: Tennessee Reef, 313 m HOLOTYPE.

**IOS:** *Discovery* Investigations: Stn 8966 31°21'N: 10°41·5'W 686–742 m 6 specimens; Stn 9015 28°46·8'N: 12°47·4'W, 610–637 m 10 specimens; Stn 9016 28°55·7'N: 12°37·1'W, 873–898 m.

**BMNH:** HMS *Challenger* Stn 236 34°58'N: 139°30'E 756–1395 HOLOTYPE of *A. iris*.

The disk is round, indented over the arms, covered with small scales, disk diameter up to 7 mm. The centrodorsal and primary plates usually indistinct. The radial shields are about 3 times as long as broad and fully separated. They extend for about half the radius of the disk. The ventral interradiar areas are covered by small scales.

The infradental papillae are conical often contiguous. The distal oral papillae are large and scale-like but in some specimens may be missing altogether. The adoral shields are wing-like often not separating the oral shield from the first lateral arm plate. The oral shield is rounded triangular with a slight distal lobe.

The dorsal arm plates are oval or slightly fan shaped, at least the proximal ones are usually contiguous. The ventral arm plates are hexagonal, almost pentagonal with the proximal angle square off, and contiguous. The tentacle pores are large with a round tentacle scale. There are 4–5 arm spines of which the ventralmost is usually the longest and often sabre shaped.

**REMARKS.** This species is characterised by the long ventralmost arm spine, the shape of the distal oral papillae and having one tentacle scale on each pore. Mortensen (1927) first speculated on the possibility that *A. iris* and *A. josephinae* were conspecific at least in the Atlantic. A comparison of the type of *A. grandisquama* and *A. iris* does not reveal any distinguishing characters and it is concluded that they are conspecific.

**DISTRIBUTION.** This species has been recorded from the Atlantic, Indian and Pacific Oceans. In the western Atlantic it has been described from the West Indies (325 m), from various localities off North America at depths of between 425–818 m; in the eastern Atlantic it has been recorded from Iceland south to the Azores and Cape Verde Islands at depths of 861–1635 m. It was recorded in shallow water (20–55 m) from the Gulf of Guinea (Madsen, 1970) while in the South Atlantic from Gough I. In the Indian Ocean it has been collected from the Gulf of Aden at depths of 655–732 m and from the Philippine area of the West Pacific.

*Amphiura chiajei* Forbes, 1843

Fig. 34

*Amphiura chiajei* Forbes, 1843: 151; Bell, 1892: 119; Mortensen, 1927: 212; Madsen, 1970: 167–168.

**MATERIAL STUDIED.** BMNH: Off Marseille 40–60 m 11 individuals.



The disk is covered with scales which become smaller towards edge, disk diameter up to 10–11 mm. The centrodorsal and primary plates are generally distinct. The radial shields are about 1.5–2 times as long as broad, separated for their whole length. The ventral interradiial areas are covered with small plates.

The infradental papillae are square and usually contiguous in larger specimens more conical in smaller ones. The first oral tentacle scales are not very calcified having a slightly membranous appearance, and well within the mouth slit. The distal oral papillae are broad and scale-like. The adoral shields are wing-like usually separating the oral shield from the first lateral arm plate. The oral shield may be rhombic or rounded triangular with only a slight distal projection.

The dorsal arm plates are fan shaped and at least the proximal ones are usually contiguous. The ventral arm plates are an irregular pentagonal or hexagonal shape, often keeled, with the distal edge sometimes indented. The tentacle pores are large with two large tentacle scales. There are up to 8 straight pointed arm spines.

**DISTRIBUTION.** This species has been recorded from the eastern Atlantic, and Mediterranean, and from West Africa. It is usually a shelf species but has been recorded from a depth of 1200 m so is included in this study.

*Amphiura richardi* Koehler, 1896c

Fig. 34

*Amphiura richardi* Koehler, 1896c: 245; 1907: 279–280; 1909: 178–179; Mortensen, 1927: 210; Nobre, 1931: 86; Cherbonnier, 1970: 1267, 1270.

**MATERIAL STUDIED.** MNHN: *Talisman* 1881 drg. 39, 33°5'N: 9°25'40"W, 1225 m 1 specimen.

The disk is pentagonal, indented interradially, covered with quite large overlapping or contiguous scales amongst which the centrodorsal plate is usually distinct, disk diameter up to 8 m. The radial shields are slightly less than half the disk radius and about three times longer than broad. Only the distal half of the ventral interradiial area has scales, it is naked proximally.

The infradental papillae are block-like and contiguous. The first oral tentacle scale, situated within the mouth slit, is distinctly spine-like. The distal oral papillae are large scale-like with a pointed free end and arising on the adoral shield and oral plate. The oral shield is rounded with an acute proximal angle, it is separated from the first lateral arm plate by the wing-like adoral shields.

The dorsal arm plates are hexagonal and contiguous at least proximally, distally they become fan shaped. The ventral arm plates are hexagonal, approaching a pentagonal shape, and contiguous. The tentacle pores are large with two tentacle scales. There are 3 arm spines of which the middle one is distinctly enlarged and may be laterally compressed.

**REMARKS.** This species is characterised by the number and shape of the arm spines and by the large distal oral papillae.

**DISTRIBUTION:** This rare species has been recorded from the Bay of Biscay, off northern Spain and the Canary Islands. It has a bathymetric range of 850–1494 m.

*Amphiura griegi* Mortensen, 1920

Fig. 34

*Amphiura griegi* Mortensen, 1920: 58–60; 1927: 210; Cherbonnier, 1970: 344–347; 1970: 1267; Gage *et al.*, 1983: 293.

**MATERIAL STUDIED.** SMBA: RRS *Challenger II* ABD Stn 24 56°36'N: 09°13'W 810 m 1 specimen.

The disk is deeply indented interradially, diameter up to 5.5 mm; it is covered with small scales which are slightly larger around the radial shields. The centrodorsal and primary plates are inconspicuous. The radial shields extend over half the radius of the disk and are about 3 times as long as broad. They are contiguous only distally, and separated proximally by a wedge of small scales. The scales on the disk extend just to the dorsal edge of the disk, the ventral interradiial areas are naked except for a few scales next to the genital slit.

The infradental papillae are block-like sometimes contiguous. The first oral tentacle scale, situated within the mouth slit, is distinctly spine-like. The distal oral papillae are large, triangular in shape with a broad base and a blunt tip. They arise on the border of the oral plate and the adoral shield. The adoral shields are wing-like separating the oral shield from the first lateral arm plate. The oral shield is rounded with a distinct distal lobe.

The dorsal arm plates are rounded and the proximal ones are contiguous. The ventral arm plates are hexagonal to nearly rectangular and the proximal ones are contiguous. The tentacle pores are large with 2 thin tentacle scales. There are 6–7 arm spines. They are broad and slightly flattened with blunt tips, some may have a small distal directed hook at the tip.

**REMARKS.** *A. griegi* can be recognised by the following characters: the lack of scales on the ventral interradial area, the spine-like first oral tentacle scale and oral papillae, the tentacle pores with two scales and the shape of the arm spines. Superficially this species could be confused with *A. fragilis*, *A. borealis* or *A. abyssorum*. *A. griegi* differs from all three because it has 2 tentacle scales on each pore, by the shape of the oral papillae and the shape of the arm spines. *A. griegi* has broad triangular distal papillae whereas *A. fragilis* and *A. abyssorum* have spine-like papillae and *A. borealis* has small scale-like papillae. The arm spines of *A. griegi* are broad, slightly flattened and blunt; those of *A. fragilis* are often rugose and have a serrated distal edge; the second ventralmost arm spines of *A. borealis* are widened at the tip and the arm spines are long and pointed in *A. abyssorum*.

*A. griegi* and *A. otteri* may be confused if the specimens lack a disk as the features of the oral frame are similar. However, *A. griegi* can be distinguished by the following characters: the oral papillae tend to be more triangular with a broader base, the arm spines are thicker, broader at the base, the dorsalmost become flattened and have a blunt rounded tip, those of *A. otteri* are thin and pointed.

**DISTRIBUTION.** This species has been recorded from Hardanger Fjord, Rockall Trough and Bay of Biscay, with a bathymetric range of 70–810 m.

### *Amphiura fragilis* Verrill, 1885

Fig. 35

*Amphiura fragilis* Verrill, 1885: 549; Mortensen, 1933a: 58–59; Gage *et al.*, 1983: 293.

*Amphiura denticulata* Koehler, 1898: 50; Grieg, 1903: 27; Mortensen, 1913: 358; 1927: 214.

**MATERIAL STUDIED.** USNM: *Albatross* Stn 952. Martha's Vineyard 663 m SYNTYPE; *Albatross* Stn 2025, Martha's Vineyard 430 m SYNTYPE; *Albatross* Stn 2043, off Nantucket Shoals 2640 m SYNTYPE.

SMBA: RRS *Challenger II*. Stn ABD 24 56°36'N: 9°13'W 810 m 2 specimens.

The disk is pentagonal to round not indented interradially, diameter up to 5 mm. It is covered by scales; in small specimens, disk diameter *c.* 2.5 mm, it is possible to distinguish the centrodorsal and primary plates but in larger specimens they become inconspicuous. The radial shields are about 3 times as long as broad and separated even in smaller specimens. The ventral interradial areas are completely naked.

The infradental papillae are conical in small specimens, block-like in larger ones. The distal oral papillae are small and pointed or scale-like, arising on the adoral shield. The oral shield is rounded triangular, often with a very slight distal lobe. The oral shield is separated from the first lateral arm plate by the wing-like adoral shields.

The dorsal arm plates are rounded in smaller specimens becoming hexagonal in the larger ones; they are not contiguous. The ventral arm plates are hexagonal nearly pentagonal and contiguous. The tentacle pores are large without tentacle scales. There are 6–7 arm spines proximally 4 distally. The arm spines are rugose with a serrated distal edge, often the whole arm spine may be covered with fine points. There is often a terminal distally directed hook to the spine.

**REMARKS.** This species can be recognised by the shape and number of the arm spines, the lack of tentacle scales on the tentacle pores and the lack of scales on the ventral interradial area. Mortensen (1933a) pointed out that the oral frame was subject to variation, particularly the shape and relative positions of the infradental papillae to one another.

**DISTRIBUTION.** *A. fragilis* has been found on both sides of the Atlantic: in the west it has been recorded off Martha's Vineyard north to the Davis Strait and W. Greenland at depths of 430–2640 m; in the eastern side it has been recorded from the Faeroe Channel in 750 m.



*Amphiura borealis* (G. O. Sars, 1871)

Fig. 35

*Ophiopeltis borealis* G. O. Sars, 1871: 16.*Amphiura borealis*: Ljungman, 1871: 643; Hoyle, 1885: 139; Bell 1892: 121; Grieg, 1893: 15; Mortensen, 1920: 54; Koehler, 1924: 288; Mortensen, 1927: 215; 1933a: 57; Djakanov, 1954: 85; 1967: 75.

MATERIAL STUDIED. **BMNH**: Porcupine Stn 23a 56°13'N: 14°18'W 768 m 1 specimen; Rev. A. M. Norman Collection, Norway, 3 specimens; Rev. A. M. Norman Collection, Hardanger Fjord 3 Specimens; Rev. A. M. Norman Collection, Trondheim Fjord 276–552 m 7 specimens; J. Murray Collections, Lofoten Is 110–184 m.

The disk is round to subpentagonal, disk diameter up to 6 mm; covered by small scales amongst which the centrodorsal and primary plates are inconspicuous. In some specimens the disk plates are very thin making the disk slightly transparent. The radial shields are roughly three times longer than broad, however in some specimens the extent of the radial shields is difficult to see. They are contiguous only distally and separated proximally by a wedge of scales. The ventral interradial areas are covered with thick skin.

The infradental papillae are block-like or conical sometimes contiguous. The first oral tentacle scale, situated in the mouth slit, is small and spine-like. The distal oral papillae are small and low sometimes slightly block-like. Often there are two papillae on each side. The adoral shield are wing-like and separate the oral shield from the first lateral arm plate. The oral shield is rounded, triangular. In some specimens the adoral and oral shields may be obscured by a layer of skin.

The dorsal arm plates are rounded and nearly contiguous. The ventral arm plates are hexagonal, nearly pentagonal, to rectangular and contiguous or nearly so. The tentacle pores are large. There are no tentacle scales. There are 4 arm spines on the proximal arm segments, 3 on distal segments. The second ventralmost arm spine is flattened with widened tip which may be axe shaped on some segments.

REMARKS. *A. borealis* is similar to *A. fragilis* but may be distinguished from it by the following characters: the shape of the modified arm spines which are flattened often with an axe shaped tip in *borealis*, while those of *fragilis* have a serrated edge; the number of arm spines; *borealis* has 3–4, *fragilis* has 5–7 arm spines; the distal oral papillae, which in *borealis* are small and low, often two on each side of the jaw, in *fragilis* they are slightly larger and more spine-like, with usually only one on each side of the jaw.

DISTRIBUTION. *A. borealis* has been recorded from Norway, Iceland, the Faeroe Channel and the Rockall Trough. It has a bathymetric distribution of 150–800 m.

*Amphiura filiformis* (O. F. Müller, 1776)

Fig. 35

*Asterias filiformis* O. F. Müller, 1776: 285.*Amphiura filiformis*: Lütken, 1855: 56; Bell, 1892: 117, 119; Mortensen, 1927: 214; 1933a: 57; Madsen, 1970: 179–181.*Amphiodia ascia* Mortensen, 1936: 290.

MATERIAL STUDIED. **BMNH**: Oxwich Bay, South Wales 6 specimens; off Marseille, France 40–60 m 80 specimens.

The disk is round to pentagonal, diameter up to 10 mm. The centrodorsal and primary plates are conspicuous. The radial shields are just over twice as long as broad, separated except at their distal ends. They extend for half the disk radius. The ventral interradial areas are partially naked, but in some large specimens often covered with overlapping plates.

The infradental papillae are square or sometimes conical in smaller specimens. The first oral tentacle scales are not very calcified and have a membranous appearance. They lie within the mouth slit. There are two distal oral papillae on each side of the jaw; a conspicuous spine-like one on the oral plate and a smaller scale-like one on the adoral plate which may be missing in some specimens (see Madsen, 1970: 179–181 for a discussion of this character). The oral shield has a rounded proximal edge with a slight distal lobe. It is separated from the first lateral arm plate by the wing-like adoral shields.

The dorsal arm plates are oval or weakly fan shaped contiguous only proximally. The ventral arm plates are pentagonal with the distal edge indented. The tentacle pores are large and lack tentacle scales. There are usually 5–7 arm spines proximally. The second, often third and fourth have a compressed axe-shaped tip.



DISTRIBUTION. Like *A. chiajei* this is a common NE. Atlantic species found from Norway to West Africa and in the Mediterranean. It is usually a shelf species but has been recorded from 1665 m.

*Amphiura abyssorum* Norman, 1876

Fig. 35

*Amphiura abyssorum* Norman, 1876: 215; Mortensen, 1927: 211; 1933a: 62.

*Amphiura digna* Koehler, 1907: 274; Mortensen, 1927: 211.

DESCRIPTION. In the absence of any material for study this diagnosis is based on Mortensen's (1933a) and Koehler's (1907) description.

The disk is covered with coarse imbricating plates amongst which the centrodorsal and primary plates are conspicuous, diameter up to 8 mm. The radial shields are about twice as long as broad, small triangular. The ventral interradial area is partly naked.

The infradental papillae are block-like and contiguous or small and conical. The distal oral papillae are spine-like arising on the adoral shields, occasionally there is a supplementary papilla on the oral plate (see Mortensen, 1933a, Fig. 36). The adoral shields are wing-like separating the oral shield from the first lateral arm plate. The oral shield is rounded triangular with a slight distal lobe.

The dorsal arm plates are large, fan shaped to rounded hexagonal and contiguous. The ventral arm plates are hexagonal and contiguous. There are 3 or 4 conical, pointed arm spines on proximal plates, 3 on distal ones. The tentacle pores do not have tentacle scales.

REMARKS. The features of the jaw resemble *A. otteri* and if the disk is missing *A. abyssorum* could be mistaken for it. *A. abyssorum* differs from *A. otteri* in the arm spine number, the lack of any terminal hook to these spines and a lack of tentacle scales on the tentacle pore, although in some specimens of *A. otteri* tentacle scales may be insignificant or absent from many pores. If the disk is preserved *A. abyssorum* differs further in the naked ventral interradial area and in the coarser scaling of the disk. This latter character may not be particularly useful as pointed out by Clark (1970).

DISTRIBUTION. *A. abyssorum* has only been recorded from the Eastern Atlantic and Davis Strait. It has a bathymetric range of 915–3210 m (Mortensen, 1933a).

*Amphipholis squamata* (D. Chiaje, 1829)

Fig. 36

See A. M. Clark 1970: 28–29 for discussion and synonymy of this genus and species.

MATERIAL STUDIED. COB: BIOGAS. Stn HZ: DS01 47°56'N: 7°40'W 400 m. 2 specimens.

SMBA: RRS *Challenger II* SBC 66 56°39'N: 09°23'W 1200 m 5 specimens.

BMNH: C. E. Halben coll, N. Ireland 6 specimens.

The disk is round covered by coarse scales amongst which the centrodorsal and primary plates are indistinguishable except in small individuals; diameter up to 5 mm, usually smaller. The radial shields extend about one third to half the radius of the disk. They are usually slightly longer than broad and contiguous throughout their length. The ventral interradial plates are slightly smaller than the dorsal plates and there is usually a distinct boundary between them.

The two infradental papillae are usually block-like in larger specimens, conical in the smaller, often contiguous. There are two distal oral papillae on each side of the jaw forming a continuous series with the infradental papillae. The distalmost one is broad and opercular. The oral shield is rounded triangular in small specimens almost rhombic in larger ones.

The dorsal arm plates are fan shaped, contiguous proximally, separated distally. The ventral arm plates are pentagonal to nearly triangular contiguous. The tentacle pores are small with two tentacle scales. There are 4 arm spines proximally, 3 distally.

DISTRIBUTION. This is a widespread species found in warm and temperate areas. It has previously been recorded from depths of 0–740 m but recent investigations in the Rockall Trough by the SMBA have recorded it from 1200 m.

*Amphiplus (Unioplus) daleus* (Lyman, 1879)

Fig. 36

*Amphiura dalea* Lyman, 1879: 27; 1882: 137–138; Lütken & Mortensen, 1899: 154.*Amphioplus daleus*: Verrill, 1899b: 315.*Amphichilus daleus*: Matsumoto, 1917: 177; Mortensen, 1933a: 63.*Unioplus daleus*: Fell, 1962: 16.*Amphioplus (Unioplus) daleus*: A. M. Clark, 1970: 45; Tommasi, 1976: 285–286.MATERIAL STUDIED. **BMNH**: HMS *Challenger* Stn 325 36°44'S: 46°16'W 4929 m. HOLOTYPE.**COB**: BIOGAS Stn 1: CP01 2245 m 1 specimen. BIOGAS Stn 2: DS40 3345 m 2 specimens. BIOGAS Stn 6: DS52 1 specimen. BIOVEMA: DS03 10°47'10"N: 42°41'01"W 5150 m 1 specimen.

The disk is indented interradially, diameter up to 10 mm. The disk scales are small imbricating becoming slightly larger towards the edge of the disk. The centrodorsal plate is usually conspicuous but not the primary plates. The radial shields are about twice as long as broad and contiguous only distally.

The infradental papillae are block-like usually contiguous. The first oral tentacle scale is superficial and together with the distal oral papillae forms a continuous series with the infradental papillae. The two distal oral papillae are block-like, the distalmost one is the largest and arises on the adoral shield and/or the oral plate. The oral shield is rounded triangular sometimes with a slight distal lobe. It is separated from the first lateral arm plate by the wing-like adoral shields.

The dorsal arm plates are slightly hexagonal or nearly rectangular and separated. The ventral arm plates are hexagonal, almost pentagonal but with the proximal angle squared off, to nearly square and contiguous. The tentacle pores have one large rounded tentacle scale. There are 3 conical arm spines; the middle one may be thicker and longer than the others.

REMARKS. This species looks superficially like *Amphioplus verrilli* but differs from that species by the following characters: the tentacle pores usually have a rounded tentacle scale whereas *verrilli* has no tentacle scales and the ventral arm plates are flat not ridge as in *verrilli*.

DISTRIBUTION. *A. daleus* appears to be a widespread abyssal species. In the North Atlantic it has been recorded from Iceland (2418 m) and the Bay of Biscay (2006–3345 m). It has also been found in the South Atlantic, off Patagonia (4929 m. Type locality) and in the eastern Pacific, off southern California and Mexico (2736–4151 m).

*Amphioplus verrilli* (Lyman, 1879)

Fig. 36

*Amphiura verrilli* Lyman, 1879: 29–30; 1882: 139–140.*Silax verrilli*: Fell, 1962: 16; Clark, 1970: 36–37.*Silax pulvinus* Cherbonnier & Sibuet, 1972: 1372–1375.*Amphioplus verrilli*: Bartsch, 1983b: 14–15.MATERIAL STUDIED. **BMNH**: HMS *Challenger* Stn 54 34°51'N: 63°59'W 4846 m HOLOTYPE.**MNHN**: *Jean Charrot* 52°06'03"N: 45°33'01"W 4165 m HOLOTYPE of *Silax pulvinus***COB**: BIOGAS Stn 3: CV14 4252 m 1 specimen. BIOGAS Stn 4: CP15 4715 m 2 specimens; CP16 4825 m 1 specimen; CP17 4706 m 1 specimen. BIOVEMA CP02 10°59'N: 45°15'W 5073 m 5 specimens; 10°46'23"N: 42°40'4W 5100 m 4 specimens; DS05 10°45'97"N: 42°40'29W 5100 m 1 specimen.

The disk is pentagonal, often indented interradially particularly in larger specimens, diameter up to 13.5 mm. The disk is covered with many small imbricating or contiguous scales amongst which the centrodorsal plate and sometimes the primary plates are distinct. The radial shields are about twice as long as broad; in small specimens they may be contiguous along their whole length, in larger specimens they become separated by a single triangular plate or by a wedge of plates. The ventral interradiial areas are covered by plates similar to those on the dorsal surface.

The infradental papillae are block-like usually contiguous lying above the broad rectangular teeth, but in smaller specimens these papillae may lie on the same level as the first tooth and be separated by it. The first oral tentacle scale is superficial and arises just distal to the infradental papillae and the two block-like distal papillae form a continuous series with the infradental papilla. The distalmost papillae are usually enlarged. The adoral shields are flared distally and separate the oral shields from the first lateral arm plate. The oral shields range from rounded triangular, particularly in small individuals, to distinctly triangular, almost a regular isosceles triangle, in some larger specimens.



The dorsal arm plates are hexagonal, with angular pointed proximal and distal edges and straight lateral sides, sometimes becoming nearly rectangular. The lateral arm plates appear to have a more open calcite skeleton giving the plate a spongy appearance. The ventral arm plates are keeled rounded pentagonal to nearly square in shape and contiguous. The tentacle pores are large and lack tentacle scales. There are 4–5 short conical arm spines proximally, 3 distally.

**REMARKS.** Cherbonnier & Sibuet (1972) consider *S. pulvinus* to be distinct from *S. verrilli* because the infradental papillae lie above the teeth and are contiguous, not lying on the same level as and separated by the ventral most tooth as in Lyman's holotype, and the ventralmost tooth, i.e. the one next to the infradental papillae is block-like whereas in the holotype of *S. verrilli* it is tricuspid. However material from the Biogas reveals, as pointed out by Bartsch (1983b), that such differences are partly attributable to size and that the tooth shape is not constant. Several specimens have contiguous block-like infradental papillae with tricuspid teeth.

**DISTRIBUTION.** *A. verrilli* has been recorded from both sides of the Atlantic: in the west from St Vincent (763 m), off N. Carolina and the Labrador Basin (4165–4864 m), in the east it has been recorded from the Bay of Biscay and the Iberian Basin (4252–5315 m). Apart from the record from St Vincent *verrilli* appears to be a member of the lower abyssal zone fauna.

### AMPHILIPIDINAE

#### *Amphilepis ingolfiana* Mortensen, 1933a

Fig. 37

*Amphilepis ingolfiana* Mortensen, 1933a: 54–56; Schoener, 1967: 655–658; Gage *et al.*, 1983: 293–294.

*Amphilepis norvegica*? Ljungman, 1872: 632; ?Lyman, 1882: 149; ?Koehler, 1914: 42; ?Cherbonnier & Sibuet, 1972: 1375 [non *A. norvegica* (Ljungman, 1867)].

**MATERIAL STUDIED.** **COB:** BIOGAS Stn 1: DS18 2325 m 5 specimens; DS17 2103 m 1 specimen; DS62 2175 m 4 specimens. Stn 2: CP11 3056 m 2 specimens. Stn 3: DS76 4228 m 2 specimens; CV12 4252 m 1 specimen. Stn 4: CP16 4825 m 1 specimen. Stn 6: DS51 2430 m 3 specimens; DS52 2006 m 6 specimens. DS70 2150 m 1 specimen; CP07 2170 m 1 specimen; CP24 1995 m 3 specimens.

**INCAL:** DS01 57°59'7N: 10°39'8W 2091 m 31 specimens; DS02 57°58'8N: 10°48'5W 2081 m 53 specimens; DS05 56°28'1N: 11°11'7W 2494 m 12 specimens; DS06 56°26'6N: 11°10'5W 2494 m 1 specimen; DS09 55°07'7N: 12°53'6W 2897 m 1 specimen; DS10 50°12'7N: 13°16'6W 2719 m 6 specimens; DS13 46°01'9N: 10°17'9W 4822 m 1 specimen; DS16 47°30'9N: 9°35'3W 4182 m 11 specimens. CP01 57°57'7N: 10°55'W 2068 m 4 specimens; CP02 57°58'4N: 10°42'8W 2091 m 1 specimen; CP03 56°38'N: 11°06'4W 2466 m 3 specimens; CP04 56°33'2N: 11°11'3W 2483 m 1 specimen; CP05 55°00'4N: 12°29'4W 2884 m 1 specimen; CP06 55°02'3N: 12°40'3W 2888 m 4 specimens; CP07 55°03'4N: 12°46'2W 2 specimens; CP08 50°14'7N: 13°13'5W 2644 m 84 specimens; CP09 50°15'4N: 13°15'8W 2659 m 37 specimens; CP12 46°00'5N: 10°18'3W 4796 m 1 specimen; CP13 46°02'1N: 10°14'8W 4800 m 3 specimens. WS01 50°19'4: 13°08'1W 2550 m 76 specimens; WS02 50°19'3N: 12°55'8W 2498 m 95 specimens; WS05 46°03'0N: 10°15'7W 4804 m 1 specimen. ØS01 50°19'4N: 13°10'9W 2634 m 18 specimens; ØS02 48°19'2N: 15°15'9W 4929 m 1 specimen; ØS04 46°03'9N: 10°12'8W 4796 m 46 specimens; ØS07 47°31'8N: 9°34'3W 4249 m 10 specimens; ØS08 47°29'8N: 9°39'2W 4327 m 1 specimen.

**IOS:** *Discovery* Investigations Stn 7709/73 60°7'1N: 19°30'3'W 2649–2663 m 1 specimen; Stn 8519/7 24°02'N: 16°59'W 997–1037 m 4 specimens; Stn 8521/6 20°48'N: 18°53'W 3064–3070 m 3 specimens.

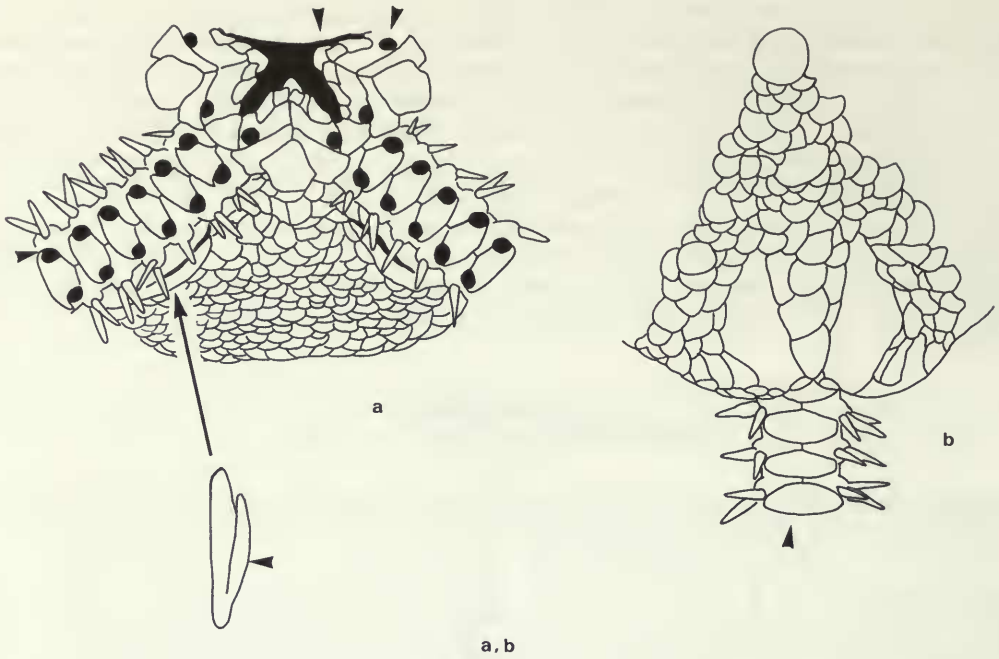
**SMBA:** *RRS Challenger II* Stn ES8 54°45'N: 12°10'W 2900 m 1 specimen; Stn ES10 56°37'N: 10°04'W 2540 m 19 specimens; Stn 56 54°40'N: 12°16'W 2886 m 2 specimens.

The disk is round, flat covered with overlapping plates amongst which primary plates, certainly the centrodorsal plate, are generally distinct. The radial shields are long, about a half the disk radius in length, longer than broad, rounded proximally and separated by a wedge of plates.

At the apex of the jaw the ventralmost tooth may be superficial, separating, the infradental papillae so that it appears to be an apical papilla; in other specimens the infradental papillae lie closer together; they are followed on each side by two block-like oral papillae. The second oral tentacle pore arises superficially outside the mouth and is open without a tentacle scale, except in juveniles where there is one pointed spine-like scale arising on the adoral shield. The adoral shields are longer than broad, flared distally. The oral shield is triangular. There are no genital slits but the genital plate has two branches: a long one lying adjacent to the arm and a slightly shorter one lying adjacent to that with only a small slit between them.



## AMPHILEPIDINAE

*Amphilepis ingolfiana*

**Fig. 37** Key to the Amphiuroidae: Amphilepidinae. *Amphilepis*: (a) ventral; (b) dorsal view of disk. Bar scales = 1 mm.

The arms are about 5–6 times the disk diameter in length. The dorsal arm plates are oblong, wider than long and separated from one another. The ventral arm plates are pentagonal in juveniles becoming more rectangular in larger specimens, and are separated from one another. The tentacle pores are open without tentacle scales. There are three pointed arm spines.

**REMARKS.** *A. ingolfiana* can be distinguished from other amphiuroid genera and certain ophiurids, to which it bears a superficial resemblance because of the superficial second oral tentacle pore, by the scaling of the disk, the arrangement of the oral plates, the lack of tentacle scales and the erect arm spines. Mortensen (1933a) noted that *A. ingolfiana* and *A. norvegica* were very similar and could only be distinguished from one another by the following characters: the shape of the genital plate which has two branches in *A. ingolfiana* but in *A. norvegica* the abradial branch—the one on the ventral interradiial side of the genital plate is reduced and broadened, while the radial shields which are more rounded on the proximal abradial—outer side in *A. ingolfiana* while in *A. norvegica* this side is more angular. Mortensen also noted that *A. ingolfiana* was bigger than *A. norvegica* and had coarser arms.

**DISTRIBUTION.** It has been recorded from both sides of the North Atlantic, in the west from Cape Hatteras north to the Davis Strait and SW. Iceland and in the east from the Rockall Trough south to off North Africa, with a bathymetric range of 957–4829 m.

## OPHIODERMATIDAE



a · b

**Bathypectinura heros**

Fig. 38 Key to the Ophiodermatidae. *Bathypectinura*: (a) ventral; (b) dorsal view of the disk. Bar scale = 1 mm.

## OPHIODERMATIDAE Ljungman, 1867

A family characterised by the disk covered with small plates usually completely concealed by a dense coating of granules in adult specimens; the radial shields usually visible; the oral papillae forming a continuous series with the apical papillae; the second oral tentacle scale opens within the mouth slit; the arm spines short may be numerous, and appressed to the side of the arm.

***Bathypectinura heros*** (Lyman, 1879)

Fig. 38

- Pectinura heros* Lyman, 1879: 48; 1882: 16; Koehler, 1897: 325; 1904: 9.  
*Pectinura tessellata* Lyman, 1883: 230.  
*Pectinura lacertosa* Lyman, 1883: 231.  
*Pectinura conspicua* Koehler, 1897: 322; 1899: 37; 1904: 9.  
*Pectinura modesta* Koehler, 1904: 7.  
*Ophiocrates lenta* Koehler, 1904: 19.  
*Pectinura elata* Koehler, 1906: 7; 1907: 249; Grieg, 1921: 32.  
*Ophiocrates secunda* Koehler, 1906: 1; 1907: 253; H. L. Clark, 1939: 132.  
*Bathypectinura lacertosa*: H. L. Clark, 1909: 129–130; 1915: 306; 1941: 90.  
*Bathypectinura elata*: H. L. Clark, 1909: 129–130; 1915: 306; Mortensen, 1927: 226.  
*Bathypectinura modesta*: H. L. Clark, 1909: 129–130; 1915: 306.  
*Bathypectinura conspicua*: H. L. Clark, 1909: 129–130; 1915: 306; Koehler, 1922: 342; H. L. Clark, 1939: 96.  
*Bathypectinura tessellata*: H. L. Clark, 1909: 129–130; 1915: 306.  
*Bathypectinura heros*: H. L. Clark, 1909: 129–130; 1915: 306; Hertz, 1927: 116; Shoener, 1967: 77; Rowe & Menzies, 1969: 533; Madsen, 1973: 133–143.  
*Bathypectinura gotoi* Matsumoto, 1915: 87; 1917: 320.  
*Ophiozonella brachyactis* H. L. Clark, 1939: 129.  
*Ophiocrates intervallus* Madsen, 1947: 9.

**MATERIAL STUDIED.** BMNH: HMS *Challenger* Stn 191 5°41'S: 134°4'E 1440 m HOLOTYPE. Investigator Godavery Detta 16°01'N: 81°25'E 738 m SYNTYPES of *Bathypsectinura conspicua* (Koehler, 1897).  
**IOS:** Discovery Investigations Stn 8968 31°35'N: 11°02'W 1 specimen; Stn 8971 31°47'5"N: 11°10'2"W 2432 m 16 specimens.

The disk is pentagonal; diameter up to 53 mm. Small specimens have large disk plates exposed, being only fringed with granules while in larger specimens, d.d. > c. 15 mm the plates are smaller and usually completely hidden by granules. The radial shields are oval, usually naked in all but the largest specimens. The ventral interradial areas are at first naked but become granule covered.

There are from 1 to as many as 10 (Madsen, 1973) apical oral papillae flanked on each side by 7–10 oral papillae, depending on the size of the specimen, with the distalmost becoming flat and widened. The adoral shields are overlain proximally by the oral shield but distally slightly widened, and in large specimens separate the oral shield from the first lateral arm plate. The oral shield is variable in shape from a rounded triangular to slightly pentagonal; it lies proximal to the genital slits not spanning them. The oral plates and adoral shields often have scattered granules which become more numerous in larger specimens.

The arms are up to 7 times the disk diameter. The dorsal arm plates, nearly square in small specimens, become broader than long in larger ones; the arms become increasingly ridged with size. The ventral arm plates are axe shaped to irregularly hexagonal and broadly contiguous except on the tips of the arms. The tentacle pores are large armed with one, or occasionally two, round or slightly egg shaped tentacle scales. There are 2 to 4 pointed appressed arm spines the longest may be up to one segment in length.

**REMARKS.** Madsen (1973) has dealt in detail with the range of variation in this species.

**DISTRIBUTION.** *B. heros* is a widespread species recorded in most oceans except the Arctic and Southern Oceans. In the Atlantic it has been recorded in the west from North Carolina 1920–2050 m, and in the east from the Bay of Biscay to the Azores 2100–2580 m.

### OPHIOCHITONIDAE Matsumoto, 1915

A family with a rounded flat disk covered by small imbricating plates amongst which the centrodorsal and primary plates usually distinct; the radial shields small, length less than half the radius of the disk, well separated from one another; the jaw broader or as broad as long; usually one sometimes two apical papillae flanked by 5–7 oral papillae on each side the distalmost slightly curved and extending beneath the largest oral papilla just proximal to it, it is possible that this distalmost papillae is part of the second oral tentacle pore; the adoral shields large and wing-like; the oral shield large, rounded triangular or arrow shaped, usually longer than broad; the arms long and slender; the dorsal and ventral arm plates well developed and contiguous at least proximally; the tentacle pores moderately large each armed with one or two flat leaf-like tentacle scales; usually three times long, erect arm spines, equal in length to two arm segments.

#### *Ophiochiton ternispinus* Lyman, 1883

Fig. 39

*Ophiochiton ternispinus* Lyman, 1883: 255; Hoyle, 1884: 144; Bell, 1892: 114; Mortensen, 1913: 354; H. L. Clark, 1915: 287; Grieg, 1921: 33; Mortensen, 1927: 224; 1933a: 67–69; Gage *et al.*, 1983: 294–295; Bartsch, 1983b: 15–16.

*Ophiochiton grandis* Verrill, 1884: 383; Koehler, 1914: 116.

*Ophiochiton solutus* Koehler, 1906: 16–17; 1907a: 269–271.

*Ophiozona tjalfiana* Mortensen, 1913a: 38; 1913b: 353.

*Ophiozonella tjalfiana*: Matsumoto, 1915: 294; H. L. Clark, 1915: 340; Mortensen, 1933a: 71.

**MATERIAL STUDIED.** BMNH: *Porcupine* Stn 42 49°12'N: 12°52'W 1572 m HOLOTYPE.

**IOS:** Discovery Investigations Stn 8519/7 24°02'N: 16°59'W 997–1037 m 1 specimen.

**MNHN:** *Travailleur & Talisman* 4 Juillet 1883 Stn 80 23°50'N: 19°37'W 1113 m HOLOTYPE of *O. solutus* Koehler.

**SMB:** RRS *Challenger II*: Stn AT 157 49°31'N: 13°11'W 1752 m 2 specimens; Stn AT 177 57°18'N: 10°16'W 2220 m 1 specimen; Stn AT 191 56°00'N: 13°58'W 2190 m 1 specimen; Stn AT 192 57°22'N: 12°02'W 1862 m 1 specimen.

The disk is round and flat, diameter up to 20 mm; covered with many small imbricating plates in large specimens or by fewer larger plates in smaller ones; the centrodorsal and primary plates are distinct and



## OPHIOCHITONIDAE

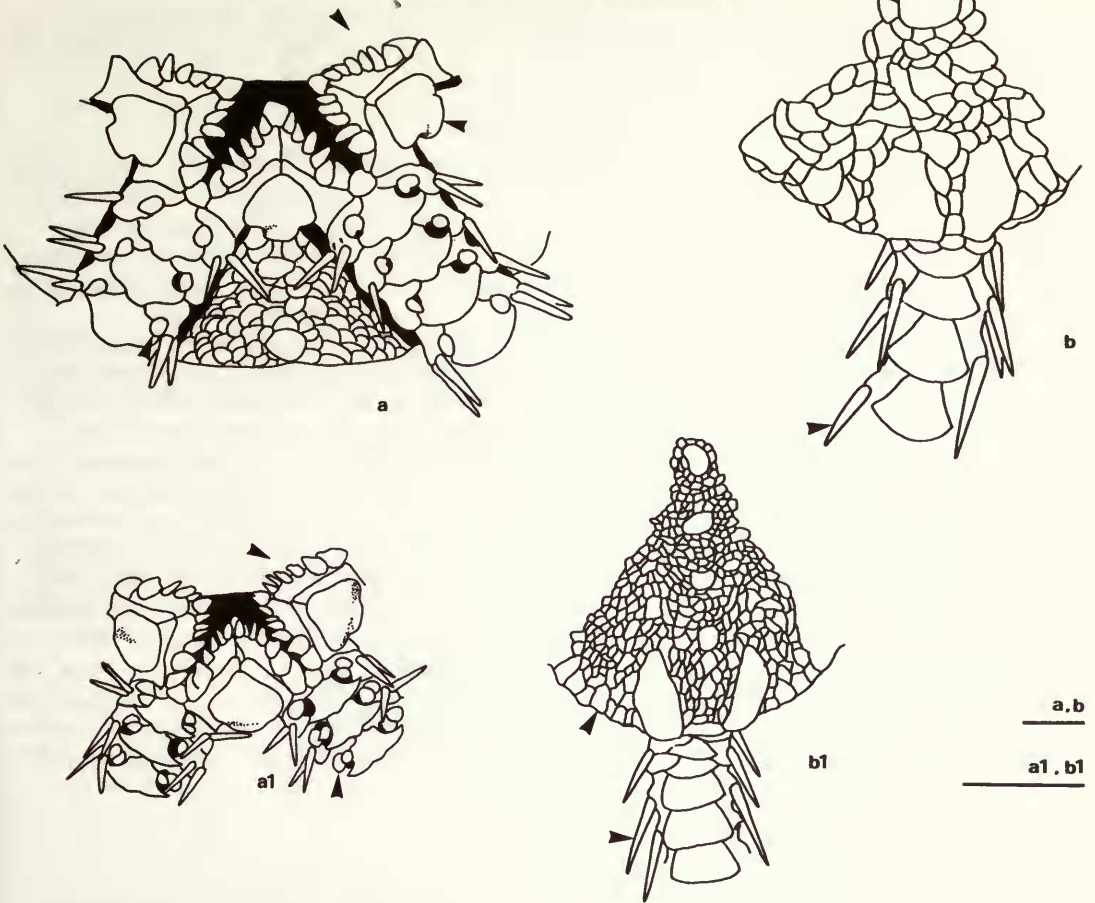
*Ophiochiton ternispinus*

Fig. 39 Key to the Ophiochitonidae. *Ophiochiton*: (a) ventral; (b) dorsal view of the disk. Bar scales = 1 mm.

larger than the surrounding plates. The radial shields are small, well separated from one another; they are usually longer than broad, slightly teardrop shaped. The ventral interradiar areas are covered with small plates similar to those of the dorsal surface.

The jaws are as broad or broader than long. There is usually one, or sometimes two, blunt apical papilla flanked on each side by 6-7 oral papillae; the proximal oral papillae are pointed and spine-like becoming broader more triangular distally. The second distalmost papillae is the largest and partly overlies the distalmost papillae when viewed from the ventral side. The distalmost papillae may appear to be slightly curved. The adoral shields are long wing-like and flared distally separating or only just separating the oral shield from the first lateral arm plate. The oral shield varies from rounded triangular to arrow shaped.

The dorsal arm plates are broader than long, contiguous at least on proximal arm segments, with a slightly convex and, in some specimens, carinate distal edge. The first ventral arm plate is small and round, the subsequent plates roughly pentagonal with a convex distal edge which may be produced in the midline; they are contiguous at least on the proximal arm segments. The tentacle pores are not conspicuously large each is armed with two sometimes only one large flat tentacle scales. There are three pointed, slightly flattened, minutely rugose arm spines of which the dorsalmost one appears to be the longest reaching nearly two arm segments in length.

REMARKS. *Ophiochiton ternispinus* can be distinguished by the shape and scaling of the disk, the structure of the jaw particularly the arrangement of the two distalmost oral papillae, the shape of the dorsal and ventral arm plates and the limited number of arm spines.

DISTRIBUTION. It has been recorded from both sides of the Atlantic; in the west from the Gulf of Mexico north to the Davis Strait with a bathymetric range of 425–1244 m and in the east from off SE. Iceland south to Azores with a bathymetric range of 1577–2220 m.

## OPHIURIDAE

The family is comprised of three subfamilies Ophiurinae, Ophiolepidinae and Ophioleucinae, reduced by Madsen (1983) from full familial rank. The features which appear to unite them are: the arm spines are short and usually appressed; the arm spine articulation is usually simple, very rudimentary; oral papillae forming a continuous series and usually either spine-like proximally becoming block-like or block-like throughout; internally the peristomal plates are double and the genital plate articulates upon the radial shield by means of two condyles and one pit.

However, the subfamilies possess characters which suggest that they should be considered as full families. The family Ophiolepidinae can be distinguished by: both oral tentacle pores arising within the mouth; the plating of the disk is usually conspicuous with large plates; and the shape of the dental plates which is twice as long as broad and rounded at both ends (Murakami, 1963).

The remaining subfamilies would appear to be more closely related from the characters of the oral and dental plates shown by Murakami (1963). The dental plates and the position of the sockets for the teeth are particularly similar. It had previously been considered that the feature of the second oral tentacle pore arising outside the mouth was distinctive enough to warrant raising the Ophiurinae to familial rank (Paterson, 1980). However, within certain species of the Ophioleucinae, e.g. *Ophiernus vallincola*, the structure and position of the second oral tentacle pore and its tentacle scales superficially resembles the arrangement found in some species of the Ophiurinae i.e. *Ophiogona döderleini*. While examination of these features reveals that the resemblance is no more than superficial there is a need to investigate the form and arrangement of both the hard skeletal structure and the soft tissues such as the tentacle and water vascular system associated with the second oral tentacle pore. Therefore, these subfamilies have not been raised to full familial rank, until more evidence is available.

### OPHIOLEUCINAE Matsumoto, 1915

A subfamily of the Ophiuridae characterised by the disk comprising scales completely or partially covered with a coat of granules sometimes also covering the radial, adoral and oral shields; the teeth are papilla-form and arranged in a single series; the second oral tentacle pore opens within the mouth slit; the adoral shields are usually long and flared distally; the oral shields are small, triangular or arrow shaped; the arms are long, often flat and wide, tapering slowly to the end of the arm; the dorsal and ventral arm plates are large and successive ones may be contiguous; the tentacle pores are variable in size, sometimes enlarged, armed with one to several scales.

#### *Ophiernus vallincola* Lyman, 1878

Fig. 40

*Ophiernus vallincola* Lyman, 1878: 122; H. L. Clark, 1923: 365; Hertz, 1927a: 114; H. L. Clark, 1939: 134.  
*Ophiernus abyssalis* Koehler, 1896c: 242; 1909: 143.

MATERIAL STUDIED. BMNH: HMS *Challenger* Stn 78 37°44'N: 25°13'W 1830 m HOLOTYPE.

IOS: *Discovery* Investigations Stn 8968 31°35'N: 11°2-0'W 12 specimens; Stn 9042 42°15'N: 11°22'W 1662–1541 m 4 specimens.

COB: BIOGAS: Stn CP34 6 specimens. INCAL: DS04 57°23-2'N: 11°06-5'W 1035 m 53 juvenile specimens.

The disk is round, sack-like being thin walled and flexible, slightly indented over the arms; covered by small imbricating scales except for the central area of the disk which is covered by a thickened wrinkled skin; diameter up to 20 mm. The scales of the disk carry a light covering of granules which never form a dense coating. The radial shields are round, naked, about a quarter of the disk radius in length.

The jaws appear long and thin. There is one long pointed apical papilla flanked by 7–10 rounded or slightly pointed oral papillae. The distal papillae appear to form a continuous series with the superficial tentacle scales of the second oral tentacle pore. This pore lies close to the surface of the jaw but within the mouth slit and has 2–3 tentacle scales. The adoral shields are flared distally separating the oral shield from the first lateral arm plate. The oral shield is rounded triangular in shape often with a slight distal projection.

The arms are long up to seven times the disk diameter, flat, and evenly taper from the base of the disk. The dorsal arm plates wider than long, rectangular and contiguous proximally. The tentacle pores are large and open proximally becoming less conspicuous distally; the first four are armed with 2–3 rounded tentacle scales, the subsequent pores usually with two pointed tentacle scales. There are two, occasionally three or four, small, appressed arm spines. The lateral arm plates also carry a series of bristle-like spines dorsal to the arm spines which are usually more noticeable in slightly dried specimens.

REMARKS. *O. vallincola* can be distinguished from *O. adpersus* by 1. The skin covered central portion of the disk; 2. the shape of the oral shield; 3. the evenly tapering arms and 4. the shape of the radial shields.

DISTRIBUTION. This is a widespread species recorded from the Pacific, Indian and Atlantic Oceans with a bathymetric range of 840–4065 m. In the North Atlantic it has been recorded from SW. Ireland, the Bay of Biscay and the Azores.

*Ophiernus adpersus adpersus* Lyman, 1883

Fig. 40

*Ophiernus adpersus* Lyman, 1883: 236; Koehler, 1897: 316; 1899: 32; 1904: 20; 1907: 251; H. L. Clark, 1911: 95; Koehler, 1914: 151; H. L. Clark, 1915: 95; Koehler, 1922: 440; Mortensen, 1927: 228; Hertz, 1927b: 112; Koehler, 1930: 280; H. L. Clark, 1939: 133; 1941: 107; John & A. M. Clark, 1954: 159.

*Ophiernus adpersus adpersus*: Madsen, 1977: 114–116.

MATERIAL STUDIED. BMNH: Blake Stn 185 off Dominique 599 m PARATYPE.

The disk is round, slightly indented over the arms; covered with small imbricating scales which may be obscured by a dense covering of granules; diameter up to 25 mm. The radial shields are triangular to tear-drop shaped, just over a quarter the disk radius in length.

The jaws appear to be long and narrow. There is one, occasionally two, pointed apical papilla flanked by 7–9 rounded oral papillae which form a continuous series with the superficial oral tentacle scales. As in *O. vallincola*, the second oral tentacle pore lies close to the surface of the jaw but within the mouth slit. The adoral shields are flared distally, separating the oral shield from the first lateral arm plate. The oral shield is triangular often with a distinct distal projection giving the shield an arrow shaped.

The arms are about 8 times the disk diameter, flat, and widening outside the disk. The dorsal arm plates are wider than long, rectangular and contiguous. The ventral arm plates are subpentagonal and contiguous. The tentacle pores are open proximally, the first three armed with up to three rounded tentacle scales, subsequent pores have two pointed scales. There are two occasionally three short, pointed arm spines of which the dorsal most one is the longest. The lateral arm plates also carry a series of long bristle-like spines, dorsal to the arm spines.

REMARKS. *O. adpersus adpersus* can be distinguished by 1. the shape of the radial shields; 2. the granulation of the entire disk except for the radial shields; 3. the widening of the arm beyond the disk.

DISTRIBUTION. This species is known from the West Indies, Cape Verde Is also from the Indian and Pacific Oceans; bathymetric distribution of 291–3650 m.

*Ophioleuce oxycraspedon* ?Baranova, 1954

Fig. 41

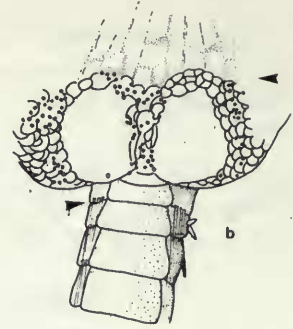
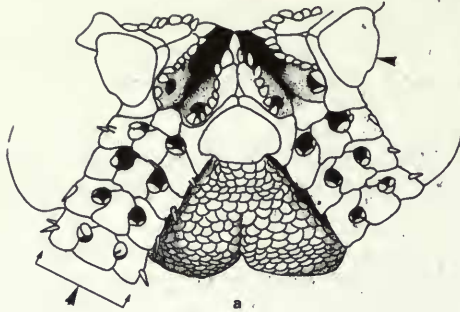
*Ophioleuce oxycraspedon* Baranova, 1954: 339; Djakanov, 1954: 128–129; Madsen, 1983: 49.

MATERIAL STUDIED. COB: BIOGAS Stn HZ: CV22 1331 m 1 specimen.

The disk is round, covered with plates which on the dorsal side of the disk are surrounded by a single row of rounded granules. Occasionally a row of larger, more elongated granules occur on the plates themselves, particularly the radial shields. Larger granules form a continuous fringe around the periphery of the disk.

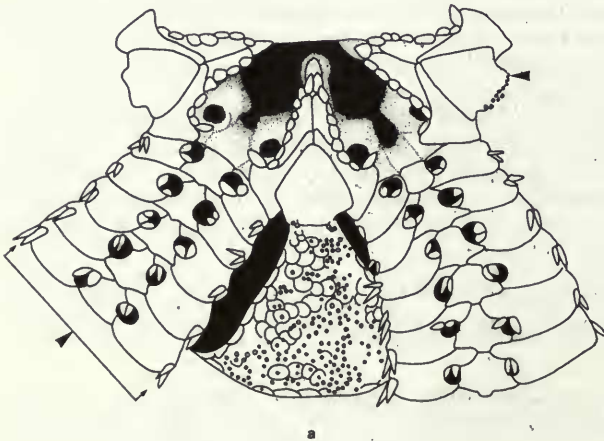


## OPHIURIDAE : OPHIOLEUCINAE



a. b

***Ophiernus vallincola***



***Ophiernus adpersus adpersus***

**Fig. 40** Key to the Ophiuridae: Ophioleucinae. *Ophiernus*: (a) ventral; (b) dorsal view of disk. Bar scales = 1 mm.

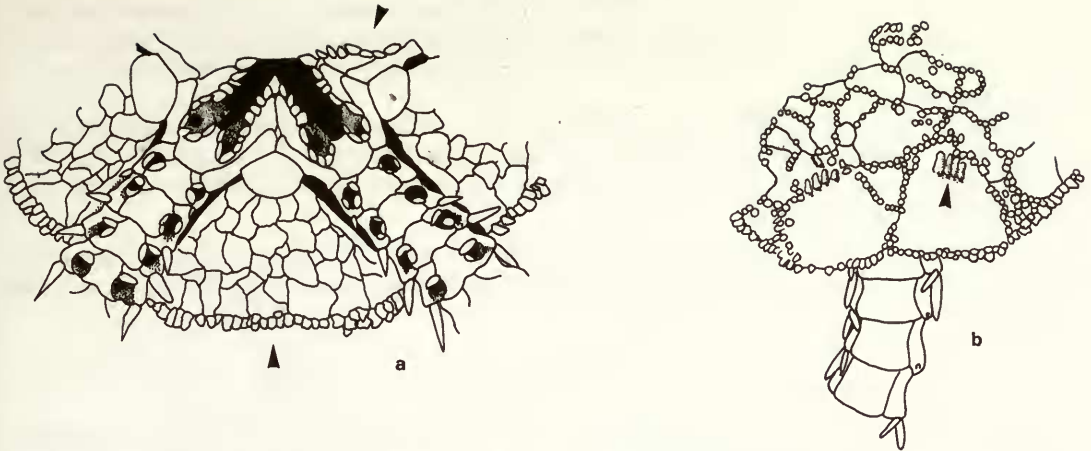
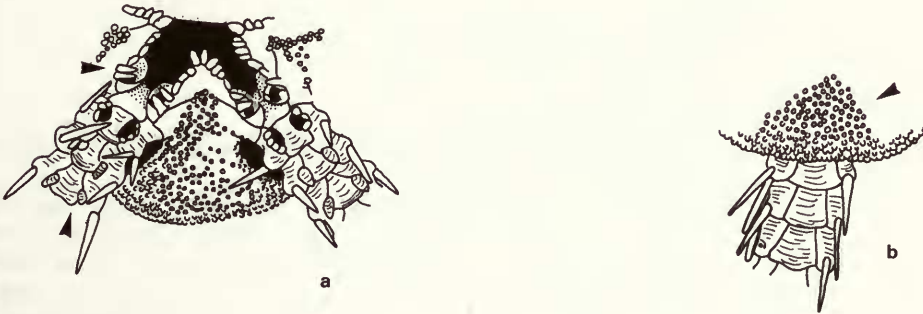
**Ophioleuce oxycraspedon****Ophiostriatus striatus \***

Fig. 41 Ophiuridae: Ophioleucinae. *Ophioleuce* and *Ophiostriatus*. Captions and scale as in Fig. 40, \*-not described in text.

Disk diameter is up to 12 mm. The radial shields are rounded triangular to teardrop shaped, slightly greater than a quarter of the disk diameter in length, distally contiguous except for a row of granules which runs along the suture. Ventral interradiar areas are covered by many quite small plates but granules are not present.

The jaws appear longer than wide. There is one large pointed apical papilla flanked on each side by 4 rounded or slightly pointed oral papillae which merge with tentacle scales associated with the nearly superficial second tentacle pore. There are 3-6 elongated tentacle scales on each side of this pore. The adoral shields are long, narrow and slightly flared distally. The oral shields are rounded, pentagonal, occasionally arrow shaped. The genital slits are large.

The arms are about 3 times the disk diameter, slightly flattened, all the plates of the arm are striated. The dorsal arm plates are rectangular, slightly longer than broad, contiguous over much of the arm. The ventral arm plates are also contiguous with a wide distal edge, which may also be slightly indented, and sloping lateral sides. The proximal tentacle pores are large; the first two are armed with 2-3 broad flap-like scales, the next two pores with 2 then only one. There are 2 arm spines situated close together, a large ventral one and a small dorsal spine.

REMARKS. The Biogas specimen appears to bear closest resemblance to *O. oxycraspedon* particularly in the granulation of the disk and the shape of the arm spines. The main differences are the number of oral papillae: up to 6 or 7 in *O. oxycraspedon* and only 4 perhaps 5 oral papillae in the Biogas specimen.

This specimen also resembles *O. gracilis* Belyaev & Litvinova, 1976 which has a similar range of enlarged granules around the periphery of the disk and arrangement of oral papillae. It differs from the Biogas specimen in the shape of the dorsal arm spines, which appear to be equal and nearly an arm segment long.

DISTRIBUTION. *O. oxycraspedon* has been recorded from north of the Commander Islands in the Northern Pacific at 2440 m, its occurrence in the North Atlantic marks a considerable extension of range.

## OPHIURINAE

A subfamily of the Ophiuridae characterised by the disk usually covered by plates sometimes with thickened skin; radial shield usually conspicuous; arm combs sometimes present; one to many apical papillae flanked by a continuous series of oral papillae; second oral tentacle pore opening outside the mouth slit or opening outside but entering the mouth slit via a furrow; oral shield variable in shape and size; arms varying size; arm spines usually less than an arm segment in length and usually appressed.

### Characters of taxonomic importance in the Ophiurinae

1. **Disk:**
  - (a) The overall plating and texture.
  - (b) The size and arrangement of the radial shields.
  - (c) The presence of arm combs, the form of the spinelets and their arrangement—particularly important in the genus *Ophiura*.
  - (d) The arrangement of the second oral tentacle pore—whether opening superficially outside the mouth slit or opening outside but entering the mouth slit via a furrow. This character, first proposed by Koehler (1904), could also be important in separating groups within *Ophiura*. Species such as *Ophiopleura borealis* have a oral tentacle pore which superficially resembles the arrangement in some species of Ophioleucinae.
  - (e) The form of the apical and other oral papillae: whether pointed or block-like, separated or contiguous.
  - (f) The length of the genital slits and form of the genital papillae.
2. **Arms:**
  - (a) The shape and length of the arm—important, particularly in separating *Amphiophiura* and *Stegophiura* from other genera.
  - (b) The form of the dorsal arm plates, whether or not contiguous or carinate.
  - (c) The shape and arrangement of the ventral arm plates—important in separating species of many genera such as *Ophiura* and *Ophiosten*.
  - (d) The form of the tentacle pores and the arrangement of the tentacle series—both useful at the generic level as in *Amphiophiura* and *Stegophiura* and the species level as in the genus *Ophiura*.

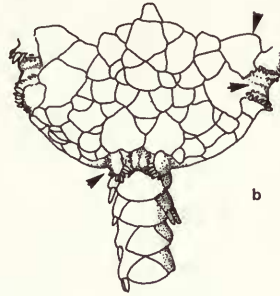
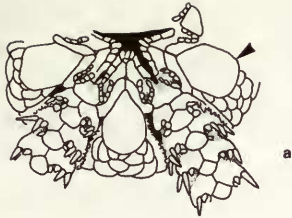
A short-hand formula is now proposed to indicate the number of tentacle scales on each arm pore on the proximal portion of the arm. Each pore is given a number starting with the proximal pores i.e. A.P. 1 = the first arm pore. The tentacle scales which arise on the lateral arm plate or on the abradial part portion of the pore furthest from the mid-line of the arm are counted, i.e. L4-5. Then those which arise on the ventral arm plate on the abradial portion of the pore nearest the mid-line of the arm i.e. V4-5.

- (e) The number, form and arrangement of the arm spines on the lateral arm plate—generally a specific character.



**OPHIURIDAE : OPHIURINAE**

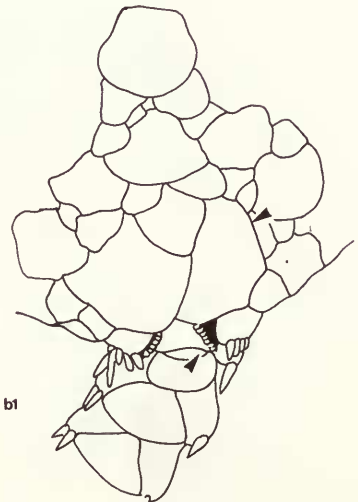
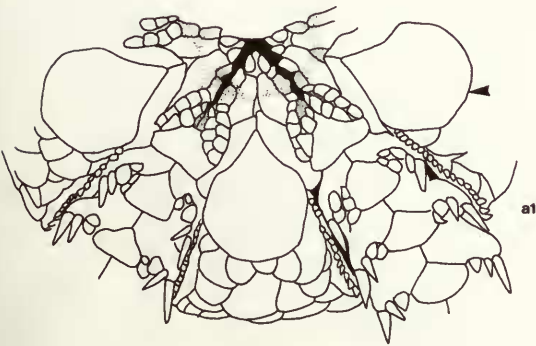
**OPHIURA**



a, b, c

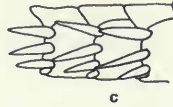
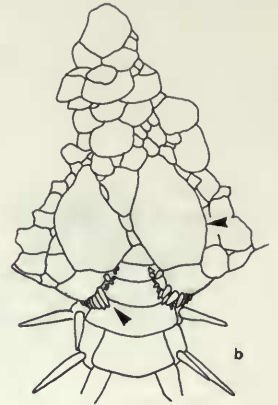
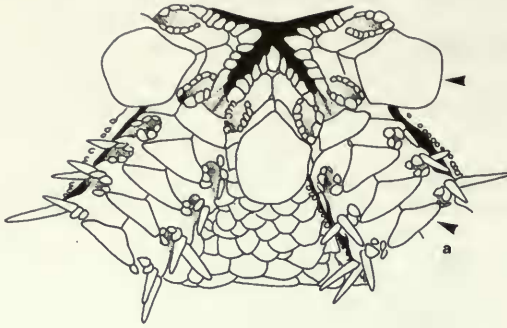
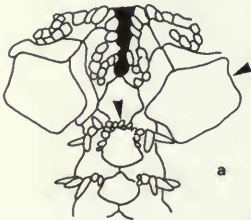
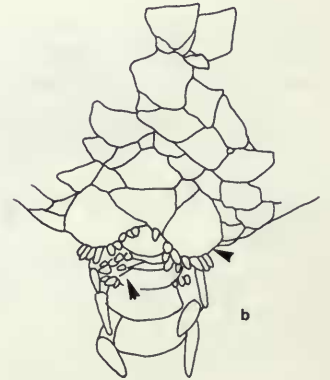
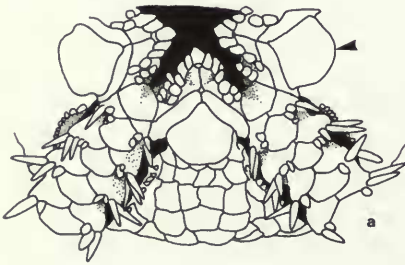
a1, b1, c1

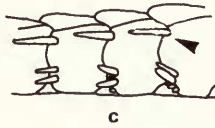
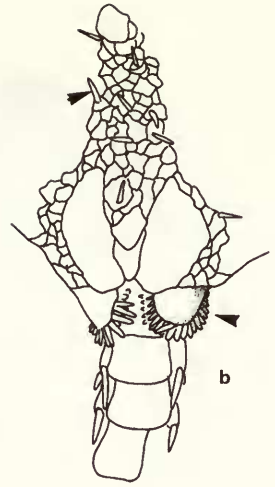
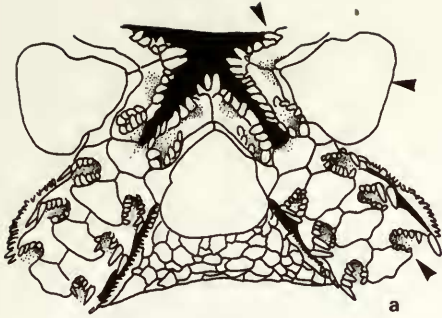
**O. carnea**



**O. imprudens**

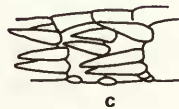
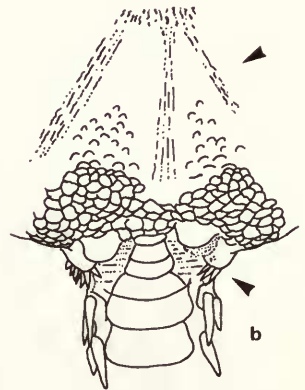
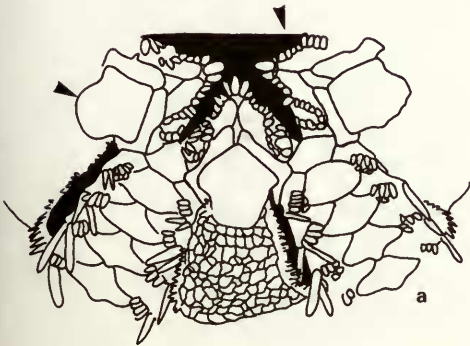
**Fig. 42** Key to the Ophiuridae: Ophiurinae. *Ophiura*: (a) ventral; (b) dorsal view of disk; (c) lateral view of arm. Bar scales = 1 mm.

***O. sarsi* \*****a, b, c*****O. robusta* \*****Fig. 43** Ophiuridae: Ophiurinae. *Ophiura*. Captions as in Fig. 42. \*—not described in text.



a, b, c

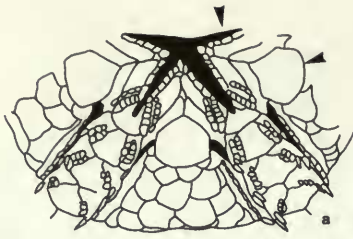
**O. Ijungmani**



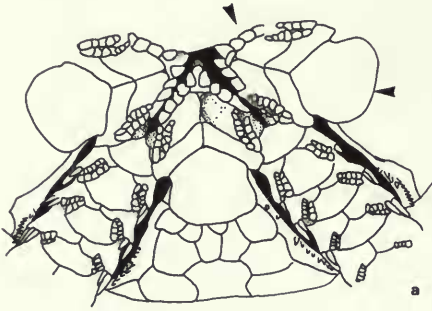
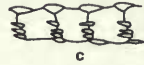
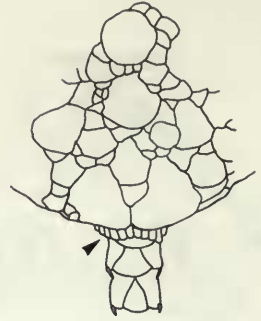
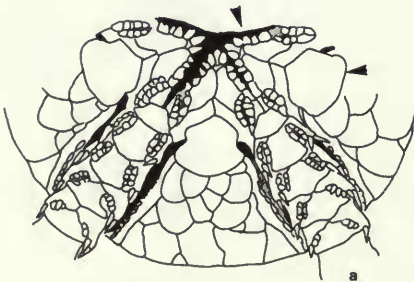
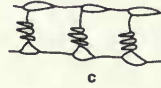
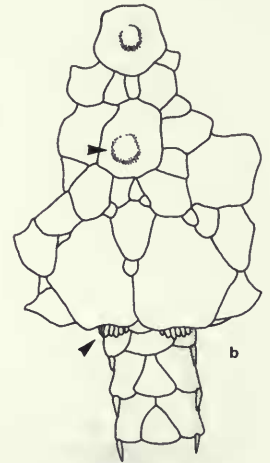
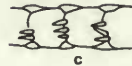
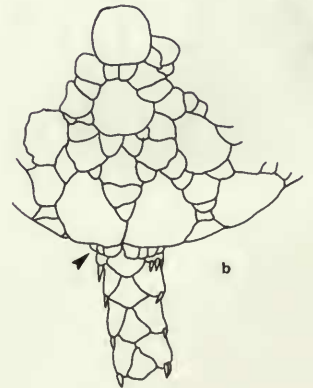
**O. flagellata**

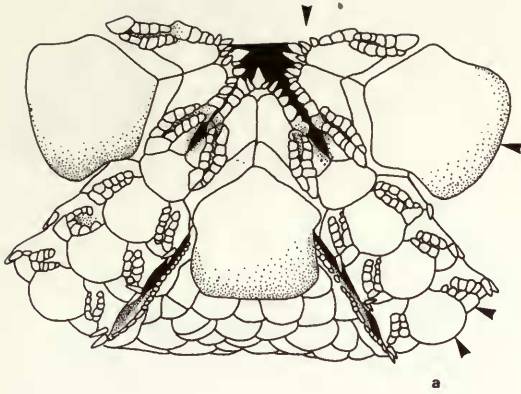
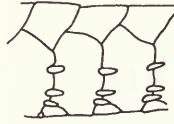
Fig. 44 Ophiuridae: Ophiurinae. *Ophiura*. Captions as in Fig. 42.



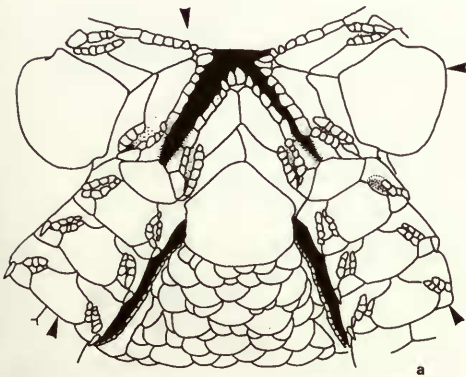
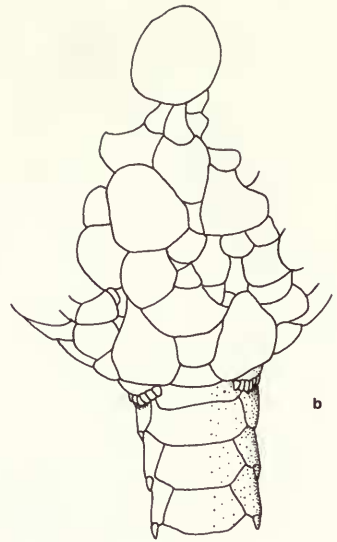
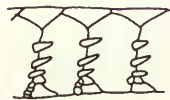
**O. clemens**

a, b, c

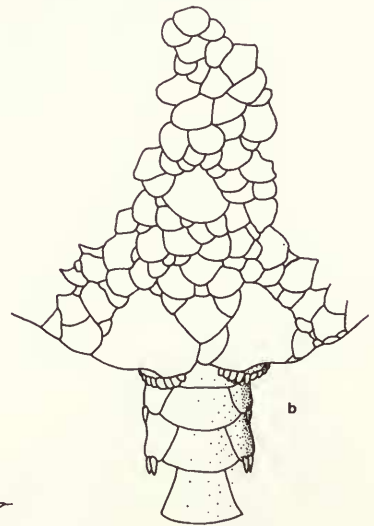
**O. nitida****O. violainae****Fig. 45** Ophiuridae: Ophiurinae. *Ophiura*. Captions as in Fig. 42.

**O. scomba**a, b, c

c

**O. irrorata irrorata**

c

**Fig. 46** Ophiuridae: Ophiurinae. *Ophiura*. Captions as in Fig. 42.

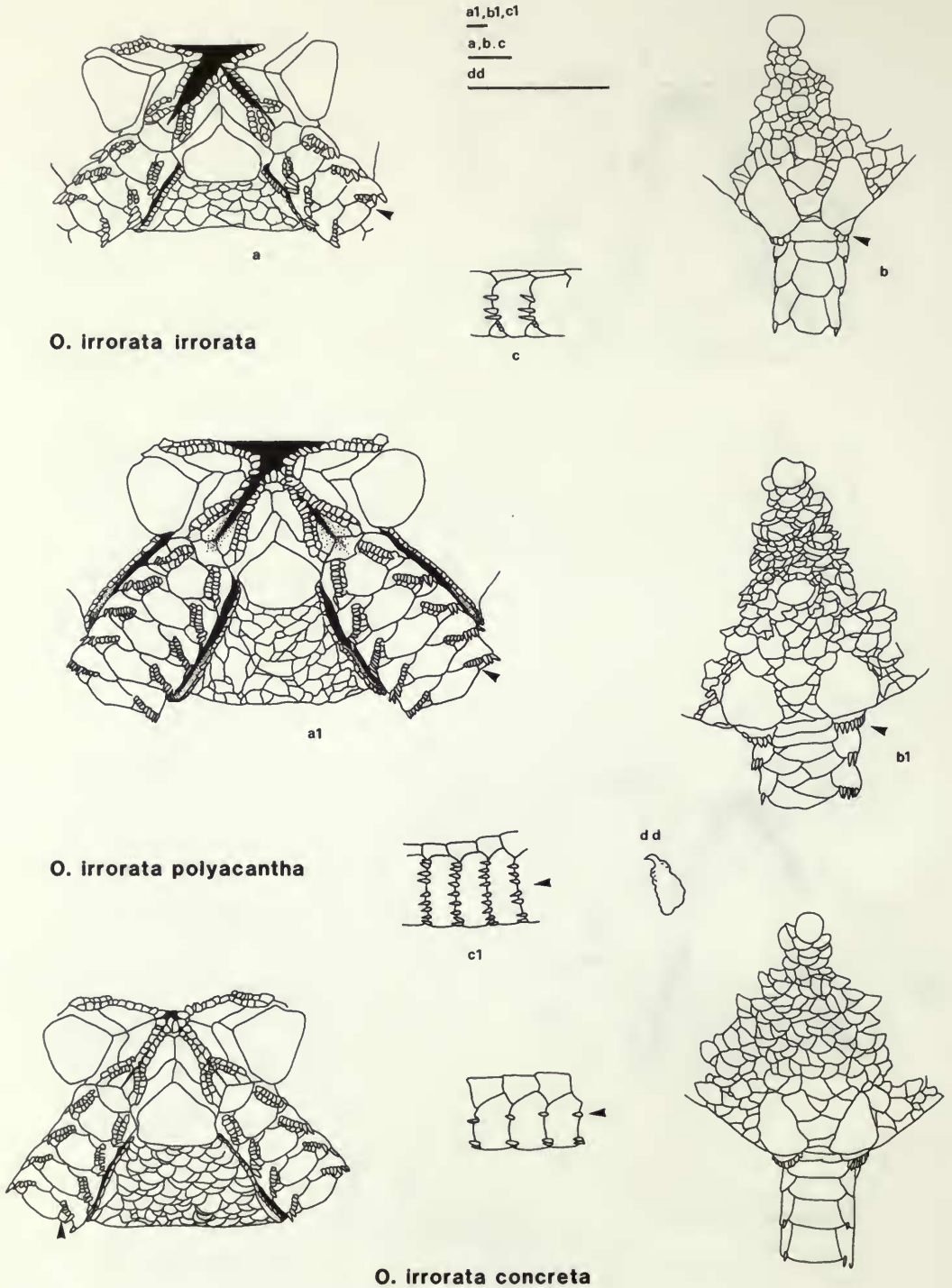
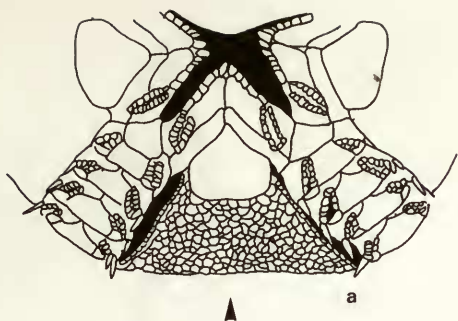
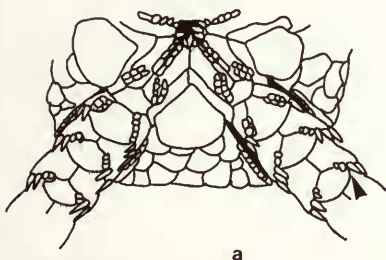
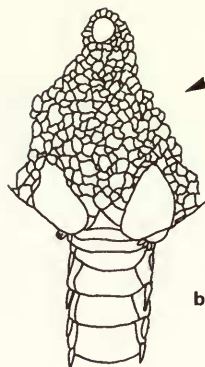
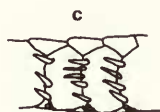


Fig. 47 Ophiuridae: Ophiurinae. *Ophiura*. Captions a-c as in Fig. 42; d, d-distal arm spine.

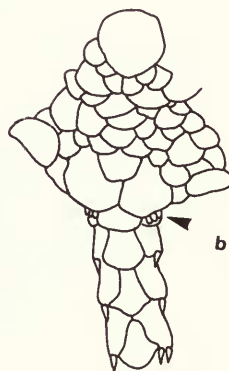
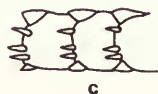




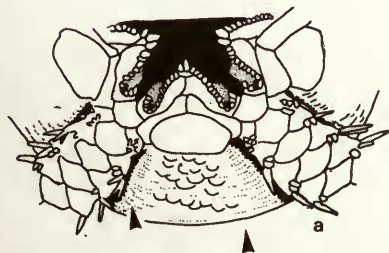
***O.irrorata loveni* \***



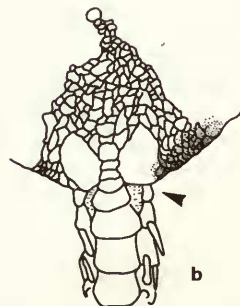
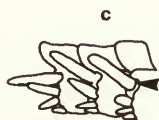
***O. mundata***



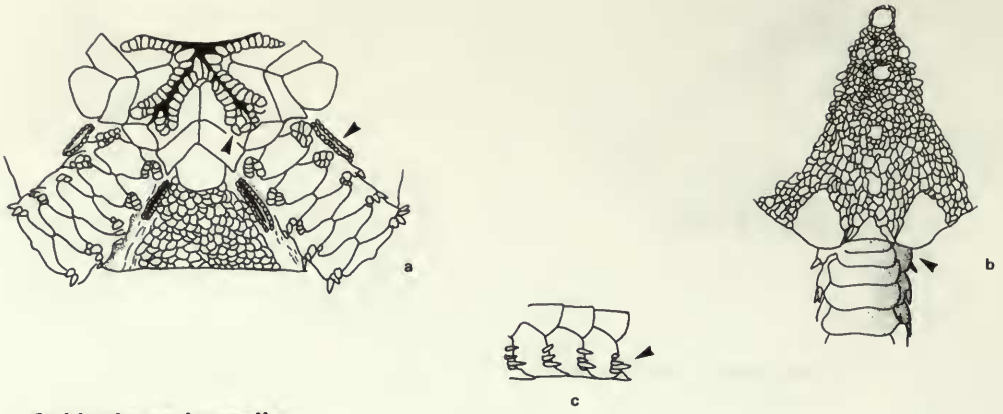
**a, b, c**



***Ophiopleura inermis***



**Fig. 48** Ophiuridae: Ophiurinae. *Ophiura* and *Ophiopleura*. \*Not described in text. Captions as in Fig. 42.



**Ophiopleura borealis**

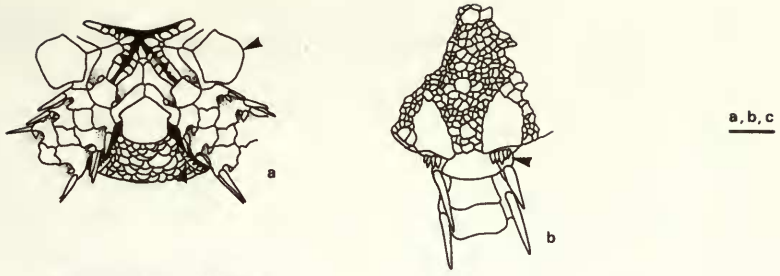


**Ophiecten hastatum**

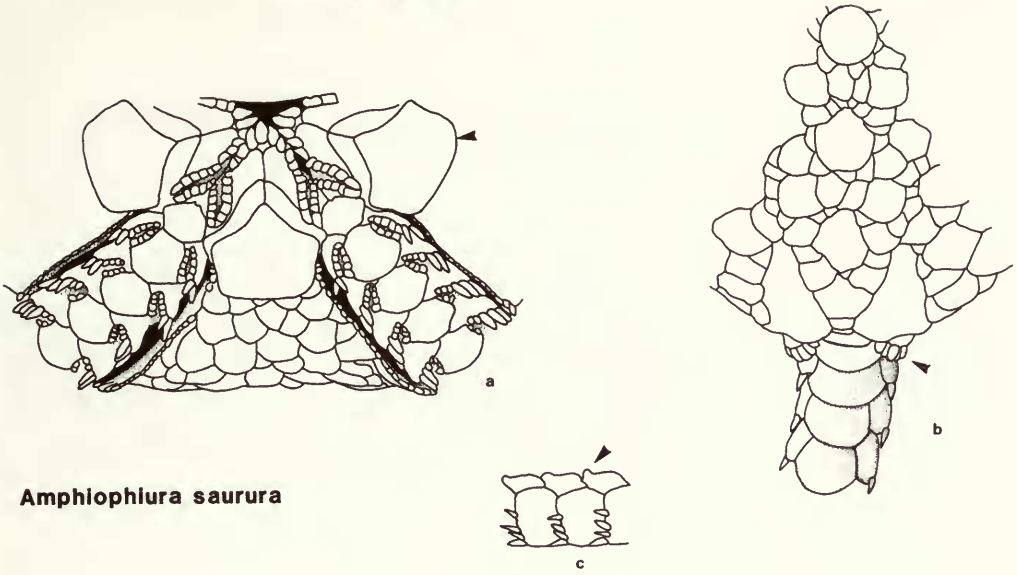


**Ophiecten centobi**

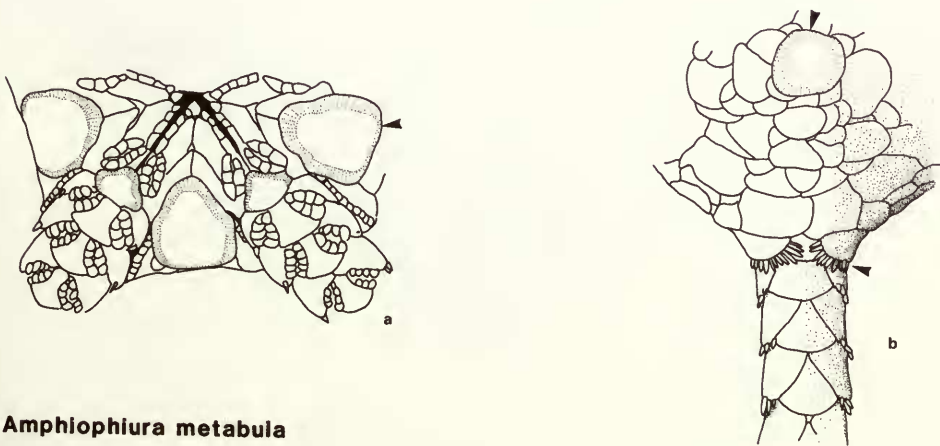
**Fig. 49** Ophiuridae: Ophiurinae. *Ophiopleura* and *Ophiecten*. Captions as in Fig. 42.



**Ophiocten gracilis**



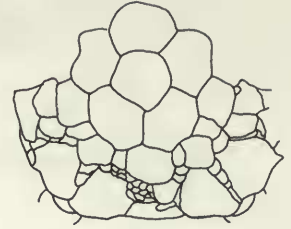
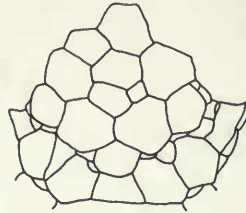
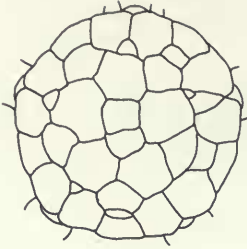
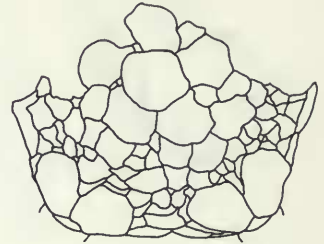
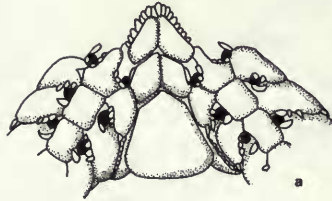
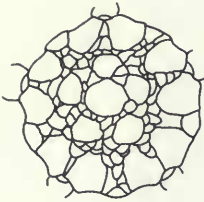
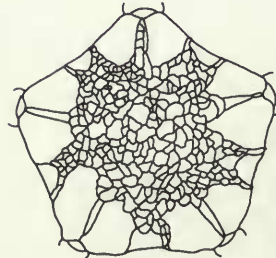
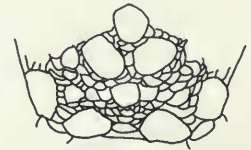
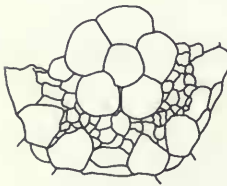
**Amphiophiura saurura**



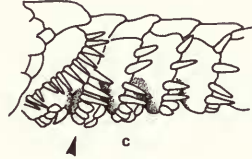
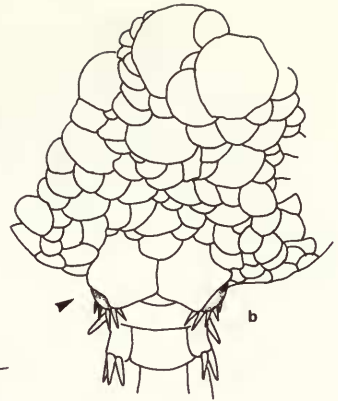
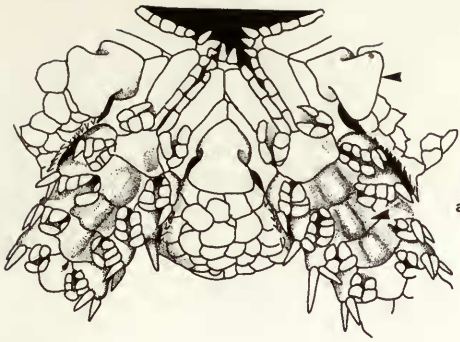
**Amphiophiura metabula**

**Fig. 50** Ophiuridae: Ophiurinae. *Ophiocten* and *Amphiophiura*. Captions as in Fig. 42.

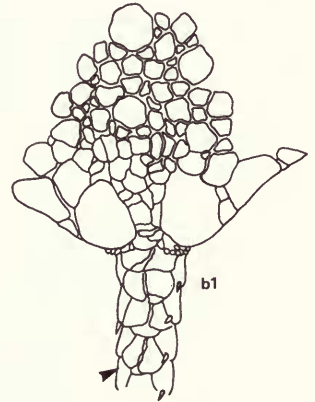
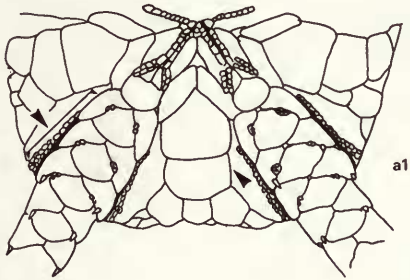


**Amphiophiura bullata complex****A. bullata convexa****A. bullata bullata****A. bullata vitjazi**

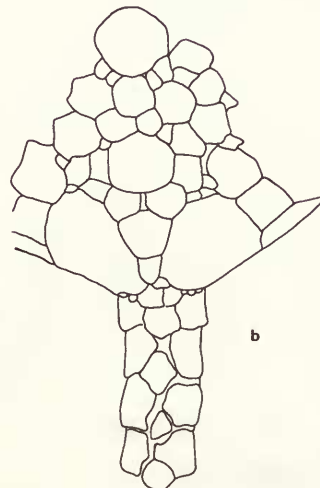
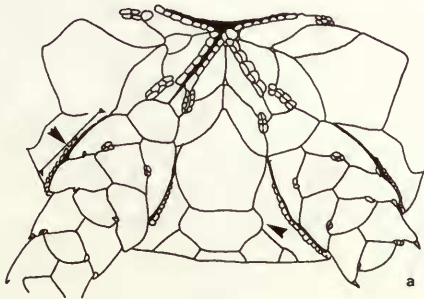
**Fig. 51** Ophiuridae: Ophiurinae. *Amphiophiura bullata* complex: (a) ventral view of disk; all other figures are dorsal views of disk.



**Stegophiura macrarthra**



**Homophiura tessellata**

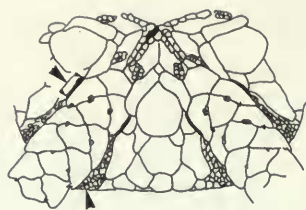


**Homophiura abyssorum**

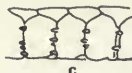
a1,b1

a,b,c

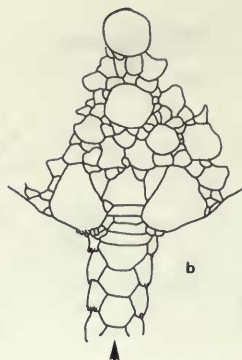
**Fig. 52** Ophiuridae: Ophiurinae. *Stegophiura* and *Homophiura*. Captions as in Fig. 42.



a

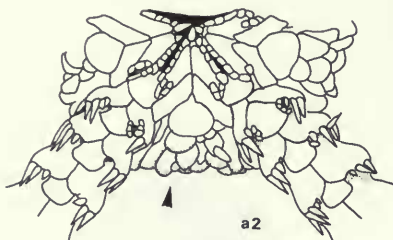


c



b

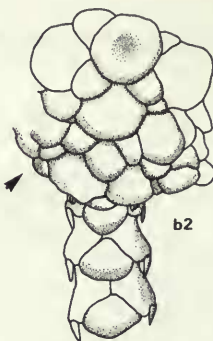
**Ophiurolepis inornata**



a2

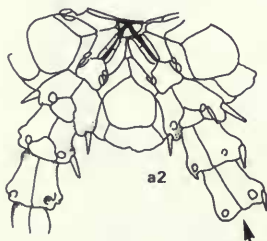


c2

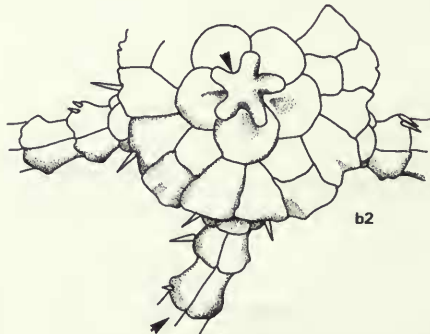


b2

**Ophiotjalfa vivipera**

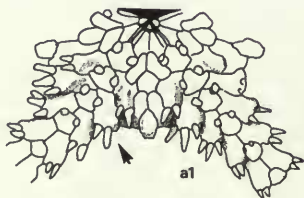


a2

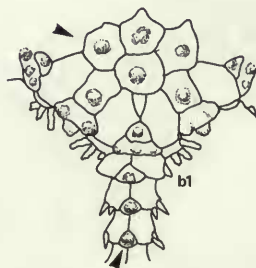


b2

**Anthophiura ingolfi**



a1



b1

**Ophiomisidium pulchellum**

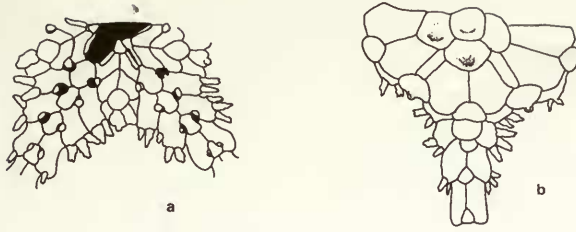
a, b, c

a1, b1

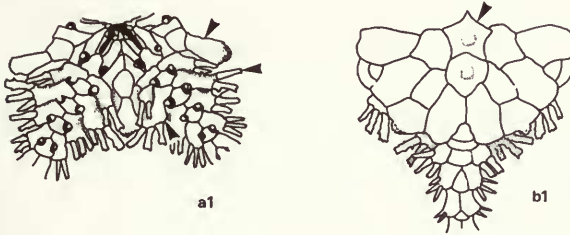
a2, b2, c2

Fig. 53 Ophiuridae: Ophiurinae. *Ophiurolepis*, *Ophiotjalfa*, *Anthophiura* and *Ophiomisidium*. Captions as in Fig. 42.





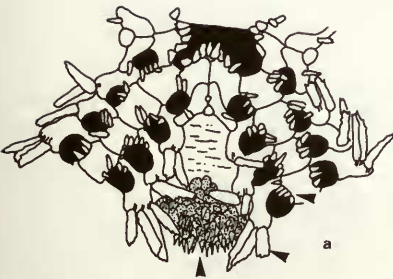
**Ophiomisidium speciosum**



a1, b1

a, b

**Ophiophyscis mirabilis**

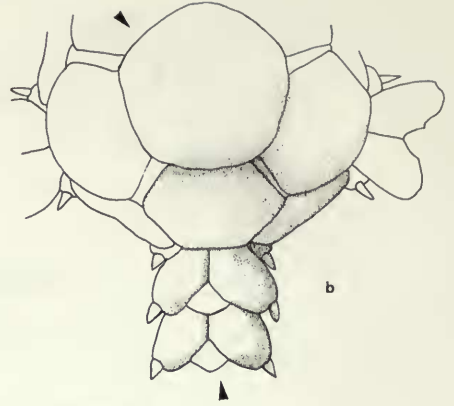
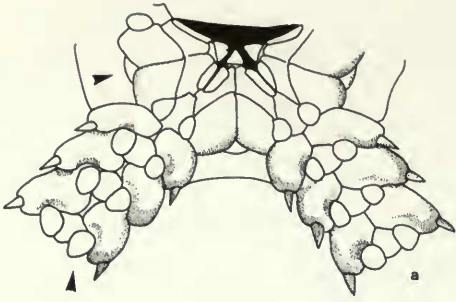
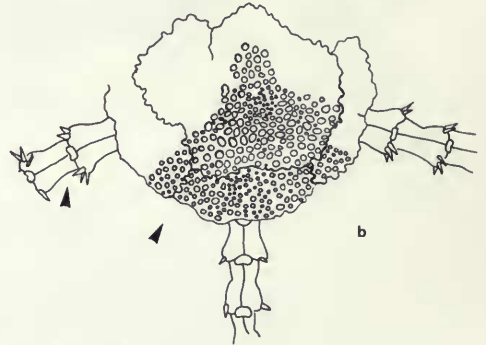
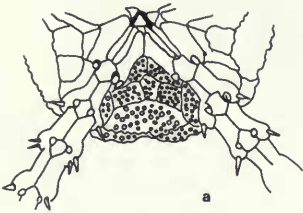
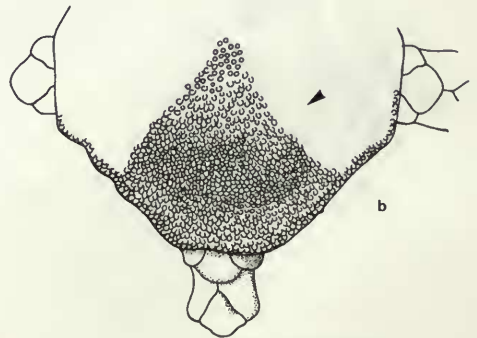
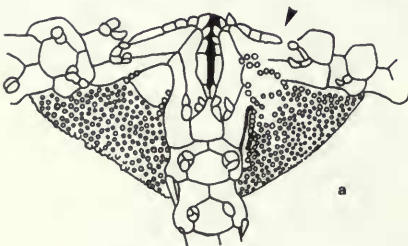


**Ophiambix meteoris**



**Ophiambix devaneyi**

**Fig. 54** Ophiuridae: Ophiurinae. *Ophiomisidium*, *Ophiophyscis* and *Ophiambix*. Captions as in Fig. 42.

**Ophiotropa simplex****Perlophiura profundissima**

a, b

**Uriopha ios****Fig. 55** Ophiuridae: Ophiurinae. *Ophiotropa*, *Perlophiura* and *Uriopha*. Captions as in Fig. 42.

*Ophiura (Dictenophiura) carnea* Lütken, 1858

Fig. 42

*Ophiura carnea* Lütken, 1858: 41; M. Sars, 1861: 24; Farran, 1913: 29; Mortensen, 1927: 243; Hertz, 1927a: 69; Gage *et al.*, 1983: 297.

*Ophioglypha carnea*: Lyman, 1865: 10; Grieg, 1893: 6; Marenzeller, 1893: 15; Koehler, 1896: 203; 1896: 241; 1898: 35; Grieg, 1902: 10; Grieg, 1905: 159; Koehler, 1906: 6; 1907: 260; Grieg, 1912: 8.

*Dictenophiura carnea*: H. L. Clark, 1923: 361.

*Ophiura (Dictenophiura) carnea*: Mortensen, 1933a: 81–82; Madsen, 1947: 13–14; 1970: 234.

MATERIAL STUDIED. **SMBA**: RRS *Challenger II* Stn ES2 55°04'N: 12°33'W 2857 m 1 specimen; AT 194 57°21'N: 11°10'W 630 m 1 specimen.

**BMNH**: *Sarsia* Bjornfjord Norway 120 m 1 specimen.

The disk is round to subpentagonal, high with almost vertical sides; covered with many plates amongst which the centrodorsal and primary plates are usually distinct; diameter up to 8 mm. The radial shields are rounded to teardrop shaped, contiguous distally about equal to a quarter of the disk radius in length, often relative smaller in larger specimens. The arm combs are prominent, extending up toward the dorsal surface of the disk; both the inner and outer comb are visible, the outer comb spinelets are conical and slightly rounded, the inner ones short and pointed. Within the notch of the arm combs are several arm plates, the innermost one sometimes indented medially or occasionally divided into two halves by a suture.

There is one pointed apical papilla flanked by one spine-like and two block-like oral papillae. The second oral tentacle pore opens outside the mouth slit and is armed with 4–5 rounded tentacle scales on each side. The adoral shields are thin, slightly bowed in appearance due to an indentation opposite the oral tentacle pore. The oral shield is approximately pentagonal with an obtuse proximal angle and a straight or convex distal edge, the shield is long extending just over half-way to the edge of the disk. The genital papillae are small, pointed, merging distally with the arm comb spinelets.

The arms are short, 2–4 times the disk diameter. The arm plates are textured with small fine inclusions in the matrix of the plate. The dorsal arm plates are fan shaped and contiguous only on the first 2–3 arm segments, the plates in profile appear to be slightly swollen. The first ventral arm plate appears trapezoidal or slightly pentagonal while the subsequent plates become more rounded with an obtuse proximal angle and a rounded distal edge; they are separated from one another. The proximal tentacle pores are large with rounded tentacle scales becoming scale-like on the proximal edge of the pore and number as follows: AP1: L2–3, V2; AP2: L1, V1; AP3+: L1, V0. There are three small, pointed arm spines; one towards the dorsal surface and the other two adjacent to the tentacle pores.

REMARKS. H. L. Clark (1923) erected *Dictenophiura* as a genus primarily characterised by the median division of the most proximal dorsal arm plate. As noted by other authors (Mortensen, 1933a; Madsen, 1970) this is not a consistent character, but Madsen considered that *Dictenophiura* should be retained as a subgenus a view shared here. *O. carnea* is compared with other bathyal species of *Ophiura* in Table 3.

DISTRIBUTION. *O. carnea* has been recorded from the Faeroes and Norway south to the Cape Verde Islands and the Mediterranean with a bathymetric range of 40–2857 m.

*Ophiura (Ophiura) imprudens* (Koehler, 1906)

Fig. 42

*Ophioglypha imprudens* Koehler, 1906: 8–10; 1907: 256.

*Ophiura imprudens*: Gage *et al.*, 1983: 298.

MATERIAL STUDIED. **MNHN**: *Travailleur & Talisman* 13 Aout 1883 Stn 123 38°23'N: 31°10'W 560 m HOLOTYPE.

**SMBA**: RRS *Challenger II*: Stn ES 113 57°18'N: 14°07'W 168 m 6 specimens.

The disk is round, flat, covered with relatively large plates amongst which the centrodorsal and primary radial plates are distinct; diameter up to 7 mm. The radial shields are large, just over half the disk radius in length, longer than broad; contiguous or sometimes overlapping. The outer arm comb consists of stout spinelets, the inner comb of smaller ones. The dorsal arm plate upon which the inner comb arises, is nearly vertical on the side of the disk.



**Table 3** Comparison of bathyal species of *Ophiura*. l = length, b = breadth, dr = disk radius

	RADIAL SHIELDS	ARM COMBS	VENTRAL ARM PLATE SHAPE	ORAL SHIELD
<i>O. albida</i>	large, $l > b$ ; contiguous distally	outer & inner present; 10–12 spinelets in outer comb	rounded triangular, contiguous	rounded pentagonal $l > b$ ; $l \geq \frac{1}{4} dr$
<i>O. sarsi</i> (Fig. 43)	large, $l > b$ ; just contiguous distally	outer & inner comb present; 9–10 spinelets in outer comb	wide triangular, contiguous	rounded pentagonal, $l > b$ ; $l > \frac{1}{4} dr$
<i>O. imprudens</i> (Fig. 42)	large, $l > b$ ; contiguous over most their length	outer & inner comb present	rounded triangular, separated	rounded pentagonal, $l > b$ ; $l = \frac{1}{2} dr$
<i>O. robusta</i> (Fig. 43)	small, $l = b$ ; separated	irregularly arranged; 8–10 spinelets with supplementary spinelets on DAP & R.S.	slightly rectangular only 1–3 contiguous	pentagonal—arrow shaped $l \approx b$ ; $l < \frac{1}{4} dr$ .
<i>O. carnea</i> (Fig. 42)	small, $l \geq b$ ; contiguous	comb almost vertical; 12 spinelets in outer comb	rounded triangular separated	rounded elongated pentagonal, $l > b$ ; $l \geq \frac{1}{2} dr$ .

The jaw appears to be depressed just distal to the apex. There is one pointed apical papilla flanked on each side by 3 oral papillae, broadening progressively from spine-like to block-like. The second oral tentacle pore is large with 4–5 rounded tentacle scales on each side. The adoral shields are about 3 times longer than broad and indented in the region of the second oral tentacle pore. The oral shield is rounded with an acute proximal angle. The genital slits are lined with relatively large pointed papillae.

The arm length is about three times the disk diameter. The dorsal arm plates are fan shaped to rounded triangular and contiguous proximally. The first ventral arm plate is triangular, subsequent ones pentagonal with the distal edge becoming more convex distally, separated along the length of the arm; the proximal ones appear to be slightly swollen. The proximal tentacle pores are large and armed with rounded tentacle scales which number as follows: A.P.1: L2–3, V2–3; A.P.2: L2, V1–2; A.P.3: L1, V1; A.P.4+: L1, V0; the distal pores appear to lack scales. There are three equally spaced pointed arm spines on the proximal segments, but they are lacking on the distalmost segments.

REMARKS. *O. imprudens* is included because it has not been figured satisfactorily and as bathyal species its distribution may extend to 1000 m. It is compared with other bathyal species of *Ophiura* in Table 3. *O. carnea* most closely resembles it and they may be conspecific.

DISTRIBUTION. This species has been recorded from the Rockall Trough and off the Azores with a bathymetric range of 168–560 m.

### *Ophiura (Ophiura) ljunghmani* (Lyman, 1878)

Fig. 44

*Ophioglypha ljunghmani* Lyman, 1878: 71; 1882: 44–45; 1883: 241; Verrill, 1885: 544; Koehler, 1896a: 71; H. L. Clark, 1901: 243; Koehler, 1907: 263; 1909: 152; 1914: 21.

*Ophioglypha lepida* Lyman, 1878: 70; 1882: 43–44; Koehler, 1914: 20.

*Ophioglypha ljunghmani* var. *spinulosa* Verrill, 1885b: 543.

*Ophioglypha thouleti* Koehler, 1896a: 69; 1909: 158.

*Ophiura lepida*: Meissner, 1901: 925.

*Ophiura ljunghmani*: Farran, 1913: 31; Mortensen, 1927: 240–242; 1932: 33; Schoener, 1967a: 647–650; Tommasi, 1970: 79–80; Lightfoot, Tyler & Gage, 1979: 970–971; Gage & Tyler, 1981: 153–161; Gage *et al.*, 1983: 298–299; Bartsch, 1983b: 17–18.

**MATERIAL STUDIED.** **BMNH:** HMS *Challenger* Stn 122 9°5'S; 34°49'W 630 m **PARATYPE**; HMS *Challenger* Stn 46 40°17'N; 66°48'W 2469 m **HOLOTYPE** of *O. lepida*; HMS *Challenger* Stn 76 38°11'N; 27°9'W 1646 m.

**COB:** BIOGAS Stn 1: DS10 2240 m 11 specimens; DS11 2205 m 6 specimens; DS13 2165 m 30 specimens; DS15 2246 m 45 specimens; DS16 2325 m 36 specimens; DS17 2103 m 9 specimens; DS18 2138 m 15 specimens; DS32 2138 m 41 specimens; DS35 2226 m 6 specimens; DS36 2147 m 15 specimens; DS37 2110 m 13 specimens; DS38 2138 m 10 specimens; DS61 2250 m 2 specimens; DS62 2175 m 47 specimens; DS63 2126 m 35 specimens; DS64 2156 m 52 specimens; DS71 2194 m 11 specimens; CV8 2180 m 6 specimens; CV09 2119 m 4 specimens; CV10 2108 m 45 specimens; CV20 2282 m 1 specimen; CV23 2034 m 11 specimens; CV24 2025 m 8 specimens; CV25 1985 m 13 specimens; CP01 2245 m 403 specimens; CP02 2177 m 2 specimens; CV39 2350 m 15 specimens; CP08 2177 m 244 specimens; CP26 2115 m 90 specimens; CP27 1920 m 1 specimen.

BIOGAS Stn 2: DS19 2865 m 73 specimens; DS41 3548 m 1737 specimens; DS57 2906 m 13 specimens; DS58 2775 m 21 specimens; DS59 2790 m 3 specimens; DS60 3742 m 2 specimens; DS66 3480 m 1 specimen; DS73 2805 m 4 specimens; DS74 2777 m 11 specimens; DS75 3250 m 6 specimens; CV37 3000 m 6 specimens; CV38 2695 m 2 specimens; CV40 2860 m 2 specimens; CP09 2171 m 56 specimens; CP10 2878 m 13 specimens; CP11 3056 m 5 specimens; CP12 2925 m 2 specimens; CP28 3380 m 3 specimens.

BIOGAS Stn 3: DS22 4144 m 2 specimens; DS67 4150 m 5 specimens.

BIOGAS Stn 6: DS25 2096 m 29 specimens; DS26 2076 m 216 specimens; DS49 1845 m 23 specimens; DS50 2124 m 43 specimens; DS51 2430 m 218 specimens; DS52 2006 m 177 specimens; DS70 2150 m 7 specimens; DS86 1950 m 81 specimens; DS87 1913 m 112 specimens; DS88 1894 m 2 specimens; CV16 1909 m 16 specimens; CV32 1895 m 2 specimens; CV33 1913 m 7 specimens; CP07 2170 m 112 specimens; CP23 1980 m 18 specimens; CP24 1995 m 10 specimens; CP25 1894 m 12 specimens.

BIOGAS Stn HZ: DS04 1100 m 2 specimens; DS05 2210 m 6 specimens; DS07 2170 m 6 specimens; DS09 2130 8 specimens; DS14 1560 m 24 specimens; CW03 2160 m 21 specimens; CV11 2141 m 8 specimens; CV22 1331 m 9 specimens.

**IOS:** *Discovery* Investigations Stn 8511/1 41°55'N; 11°15'W 2384–2399 m 1 specimen; Stn 8970 31°30'4'N; 11°4'4'W–31°30'0'N; 11°3'8'W 12 specimens; Stn 9021 30°04'2'N; 11°51'7'W 2122–2173 10 specimens; Stn 9029 32°14'3'N; 11°2'8'W–32°14'1'N; 11°2'5'W 1886–1835 m 13 specimens; Stn 9042 45°15'0'N; 11°22'0'W 1662–1541 m 5 specimens; Stn 9640/1 50°3'2'N; 13°50'6'W 34 specimens.

**SMBA:** RRS *Challenger II*: Stn ES8 54°45'N; 12°10'W 2900 m 10 specimens; Stn ES10 56°37'N; 10°04'W 2540 m 6120 juvenile specimens; Stn SBC46 55°04'N; 12°06'W 2875 m 3 specimens; Stn ES56 54°40'N; 12°16'W 2886 m 688 specimens; Stn SBC68 58°42'N; 09°43'W 1800 m 1 juvenile specimen.

The disk is pentagonal, box-like with steep sides; covered by small plates amongst which it is possible to distinguish the centrodorsal plate but not usually the primary radial plates; disk diameter up to 10 mm. There are simple spinelets scattered over the dorsal surface of the disk although they are often rubbed off in preserved specimens. The radial shields are longer than broad, extending up to half the radius of the disk in length; each pair separated by a wedge of plates. The arm combs are distinct, extending on to the dorsal side of the arm; the outer comb spinelets are thin and pointed, the inner ones small and pointed.

There are one or two pointed apical papillae at the apex of the jaw flanked on each side by 6–7 pointed oral papillae. The second oral tentacle pore is large, opening superficially away from the mouth, and is armed with 4 rounded tentacle scales on the outer edge, 6 on the inner. The adoral shields are long, narrow and slightly flared distally. The oral shield has an obtuse proximal angle, indented lateral sides and a convex distal edge; the distal portion of the shield appears enlarged, extending approximately half-way to the disk edge. The genital slits are edged with rounded papillae proximally which become more elongated and spine-like until they merge at the edge with the arm comb-spinelets.

The arms are about 3–5 times the disk diameter, and high slightly compressed laterally. The dorsal arm plates are longer than broad, rectangular proximally becoming fan shaped, and contiguous over most of the arm. The ventral arm plates are approximately rounded pentagonal in shape becoming broader than long and rectangular on distal segments and separated except occasionally for the second and third ventral plates. The tentacle pores are large and open proximally becoming smaller distally armed with rounded slightly elongated tentacle scales; they number as follows: A.P.1: L2–4, V3–5; A.P.2: L2–4, V4; A.P.3: L2–3, V0–3; A.P.4: L1–3, V0–2; A.P.5: L2, V0–1; A.P.6+: L+2, V0. Small specimens usually have tentacle scale numbers in the lower part of the range. There are three pointed arm spines, the longest one located dorsally and nearly equal in length to segment, the other two much shorter and located on the ventral portion of the arm adjacent to the tentacle pores.

**REMARKS.** *O. ljungmani* can be distinguished by the shape of the disk, the possession of disk spinelets, the form of the arm comb, the large tentacle pores, the shape of the oral shields and the



arrangement of the arm spines. See Schoener (1967) and Gage & Tyler (1981) for a discussion of the recognition of juvenile stages.

**DISTRIBUTION.** *O. ljunghmani* is a common species found on both sides of the North Atlantic often in large numbers. In the west it has been recorded from off Florida north to the Labrador Basin with a bathymetric range of 101–2750 m and in the east from SE. Iceland to North Africa with a bathymetric range of 777–4150 m. It has also been recorded off Pernambuco, Brazil, 736 m, and southern Africa.

***Ophiura flagellata* (Lyman, 1878)**

Fig. 44

*Ophioglypha flagellata* Lyman, 1878: 69; 1882: 42; Koehler, 1904: 56; 1907: 261.

*Ophiura flagellata*: H. L. Clark, 1911: 60; 1913: 208; Matsumoto, 1915: 81; H. L. Clark, 1915: 320; Koehler, 1922: 375–377.

*Gymnophiura coerulescens* Lütken & Mortensen, 1899: 114.

**MATERIAL STUDIED.** BMNH: HMS *Challenger* Stn 232 Sagami Bay, Japan 636 m HOLOTYPE; *Albatross* Stn 3431 23°59'N: 108°40'W 1791 m SYNTYPE of *Gymnophiura coerulescens* Lütken & Mortensen, 1899.

The disk is round to subpentagonal, lacking calcareous plates in the centre and often with poorly developed plates around the periphery; in some preserved specimens there appears to be interradial rays of thickened skin; diameter up to 24 mm. The radial shields are small, rounded often with only the tips visible. The arm combs are well developed; consisting of long pointed spinelets. The ventral interradial area is covered with distinct plates.

There is one rounded apical papilla, sometimes two, flanked on each side by 4–5 rounded or pointed apical papillae. The second oral tentacle pore is large lined on each side by 4–6 long rounded tentacle scales which sometimes nearly form a continuous series with the oral papillae. The adoral shields are longer than broad slightly flared distally. The oral shield is arrow shaped or light-bulb shaped and is about a quarter of the disk radius in length. The genital papillae are thin and spiniform.

The arms are 3–4 times as long as the disk diameter. The dorsal arm plates are wider than long, slightly rectangular, and contiguous. The first ventral arm plate is irregularly hexagonal, the second slightly trapezoidal with a convex distal edge, subsequent plates are wider than long axe shaped or squat bell shaped; the proximal plates are contiguous. The proximal tentacle pores are large armed with long rounded scales of which those on the lateral plate are the larger; they number as follows: A.P. 1–2: L4, V3–4; A.P. 3–4: L3, V2–3; A.P.5+: L3, V0–1. There are 3–4 flat, distally widened, pointed arm spines of which the dorsalmost one is the largest, often equal in length to 2 segments.

**REMARKS.** *O. flagellata* can be recognised by the poorly calcified disk plates, the well developed arm combs, and the shape of the oral shield.

**DISTRIBUTION.** In the North Atlantic this species has only been recorded from south of the Canaries at depths of 932–2330 m. It is also known from South Africa and the Pacific Ocean off Mexico.

***Ophiura (Ophiuroglypha) clemens* (Koehler, 1904)**

Fig. 45

*Ophioglypha clemens* Koehler, 1904: 51; 1907: 291.

*Ophiura clemens*: H. L. Clark, 1915: 319; Matsumoto, 1917: 268; Koehler, 1922: 374–375.

**MATERIAL STUDIED.** MNHN: *Travailleur & Talisman* 14th Aout 1881 Stn 38 41°11'N: 10°38'W, 4 specimens.

The disk is round, slightly domed, covered in large plates amongst which it is possible to distinguish the centrodorsal and primary radial plates; diameter up to 8 mm. The radial shields are approximately triangular, longer than broad just under half the disk radius in length, and are contiguous only distally. The arm comb comprises a single row of rounded block-like spinelets which form a continuous fringe over the base of the arms.

There is one pointed apical papilla flanked on each side by 4–5 block-like oral papillae. The second oral tentacle pore is relatively large and extends almost to the mouth slit, with 5–6 rounded block-like tentacle scales on each edge. The adoral shields are longer than broad not flared distally. The oral shield is rounded



**Table 4** Comparison of *Ophiura clemens*, *O. violainae* and *O. nitida*

SPECIES	ARM COMB	ORAL PAPILLAE	ORAL SHIELDS	ARM SPINES	PRIMARY PLATES
<i>O. clemens</i>	continuous fringe of block-like spinelets	blocklike, contiguous	rounded pentagonal	evenly spaced	no sculpting
<i>O. violainae</i>	continuous fringe of block-like spinelets	pointed, blocklike only distally	obtuse proximal angle, enlarged distal portion	evenly spaced	no sculpting
<i>O. nitida</i>	continuous fringe of conical spinelets	blocklike, contiguous	slightly arrow shaped	bunched on ventral portion of the arm	with a raised boss in centre of plate

pentagonal with an obtuse nearly acute proximal angle and a rounded distal edge, it extends less than half-way to the disk edge. The genital slits are edged with contiguous block-like papillae which merge with the arm comb spinelets.

The arms are 3–4 times the disk diameter. The dorsal arm plates are fan shaped with only the first 3 contiguous. Ventrally the proximal part of the arm appears flat. The first ventral arm plate is triangular or pentagonal with a slightly convex distal edge, the second is nearly rectangular and is longer than broad; subsequent plates are broadly pentagonal with a wide convex distal edge. Only the first three plates are contiguous. The tentacle pores are relatively large proximally, and armed with rounded block-like papillae, which number as follows: A.P.1: L4, V4; A.P.2: L3, V3; A.P.3: L3, V3; A.P.4: L2–3, V0; A.P.5: L1, V0; A.P.6+: L0, V0.

Occasionally on the second arm segment the distalmost inner tentacle scale may be enlarged to resemble a supplementary ventral arm plate. There are 3 short pointed arm spines positioned towards the ventral side of the lateral arm plate. Distally one of the arm spines is transformed into a hook.

**REMARKS.** *O. clemens* closely resembles *O. nitida* and *O. violainae*; see Table 4 for a comparison of these species.

**DISTRIBUTION.** Within the North Atlantic this species has been recorded from the Bay of Biscay at a depth of 1916 m. It has also been found in the Indo-West Pacific off the Philippines and East Indies.

***Ophiura (Ophiura) nitida* Mortensen, 1933a**

Fig. 45

*Ophiura nitida* Mortensen 1933a: 84–86.

**MATERIAL STUDIED.** ZMC: *Ingolf* Stn 18, 61°44'N: 30°29'W, 2065 m. HOLOTYPE and PARATYPE.

The disk is round, slightly indented interradially, flat, covered with large plates amongst which the centrodorsal and primary radial plates are distinct each with a raised boss in the centre; diameter up to 13 mm. The radial shields are slightly longer than broad, up to a quarter the disk radius in length, contiguous along the distal portion. The arm combs just protruding from beneath the radial shields form a continuous fringe over the base of the arms; there is only a single row of conical, sometimes blunt arm comb spinelets.

There is one, sometimes two, blunt apical papilla at the apex of the jaw, flanked by 3–4 pointed, block-like oral papillae. The adoral shields are long and broad. The second oral tentacle pore opens outside the mouth and is armed with 5–7 block-like scales on the inner side and 5 on the outer, the distalmost of which is broad and flap-like. The oral shield is approximately arrow shaped with an obtuse proximal angle and a convex edge. The genital papillae are small and blunt.

The arms are 2–3 times the disk diameter, the ventral side is nearly flat. The dorsal arm plates are fan shaped with only the first two plates being contiguous. The first two ventral arm plates are trapezoidal and contiguous the subsequent plates are pentagonal with an obtuse proximal angle and a gently convex distal

edge. Proximal tentacle pores are large; armed with round block-like papillae which number as follows: A.P.1: L4-5, V5; A.P.2: L4, V4; A.P.3: L4, V3; A.P.4: L4, V3; A.P.5-6: L3, V2; A.P.7+: L1, V0; A.P.12+: L0, V0. There are three conical arm spines situated close together towards the ventral part of the arm.

REMARKS. *O. nitida* can be recognised by the form of the primary disk plates, the form of the arm comb, and the arrangement of the arm spines. See Table 4 for comparison with *O. clemens* and *O. nitida*.

DISTRIBUTION. This species has only been recorded from the type locality on the Rekjanes Ridge, SW of Iceland at 2065 m.

*Ophiura (Ophiura) violainae* (Cherbonnier & Sibuet, 1972)

Fig. 45

*Homalophiura violainae* Cherbonnier & Sibuet, 1972: 1378.

MATERIAL STUDIED. MNHN: 'Noratlante' Stn 124, 47°29.6'N: 8°22.6'W, 2210 m. HOLOTYPE.

IOS: *Discovery* Investigations Stn 8511/1, 41°55'N: 11°15'W, 2384-2399 m. 1 specimen.

The disk is round, flat and covered by relatively large plates; the centrodorsal and the primary radial plates are conspicuous being larger than the other plates; diameter 9.5 mm. The radial shields are longer than broad, separated or contiguous only distally and extending just over a quarter of the disk radius in length. The arm comb consists of a single row of block-like spinelets which form a continuous fringe over the base of the arm.

There is one pointed apical papilla flanked on each side by 5-6 pointed oral papillae which become slightly block-like distally. The second oral tentacle pore is large and extends towards the mouth slit with 4-5 rounded tentacle scales on each side. The adoral shields are long and narrow slightly flared distally. The oral shield has an obtuse proximal angle and a convex distal edge, the distal portion is enlarged; the shield is about one-third of the disk radius in length. The genital papillae are low and block-like.

The arms are about 2-3 times the disk diameter. The dorsal arm plates are fan shaped with only the first three contiguous. The first three ventral arm plates are trapezoidal slightly longer than broad subsequent plates are more axe-shaped or slightly rectangular and are broader than long. Only the first four arm segments have distinct tentacle pores, which are armed with rounded tentacles and number as follows: A.P.1-2: L3-4, V3-4; A.P.3: L3, V3; A.P.4: L2-3, V0-2; A.P.5+: L1, V0. There are 3 closely spaced short pointed arm spines.

REMARKS. *O. violainae* resembles *O. clemens* and *O. nitida*, the 3 are compared in Table 4. *O. violainae* is transferred from *Homalophiura* for the reasons given on p. 136.

DISTRIBUTION. This species has been recorded from the northern Bay of Biscay and off Portugal at depths of 2210-2399 m.

The *Ophiura irrorata* Group

This group of species and subspecies all share the character of an enlarged distal tentacle scale on the proximal tentacle pores, which resembles a supplementary ventral arm plate. Clark (1911), Koehler (1914) and Madsen (1956) commented that the species *Ophiura irrorata* appeared to be variable particularly in the degree of scaling of the disk and dimensions of the oral shield. This has led to many species being regarded as conspecific with *O. irrorata*, i.e. *O. grandis* (Verrill, 1894), *O. involuta* (Koehler, 1898), *O. orbiculata* (Lyman, 1878) and *O. tumulosa* (Lütken & Mtsn, 1899). In view of this degree of variation it was necessary to examine other species with this character to determine their status. The species in question are *O. concreta* (Koehler, 1901b), *O. loveni* (Lyman, 1878), *Ophiuroglypha lymani* Studer, *O. ossiculata* Koehler, 1922 and *O. plana* (Lütken & Mtsn, 1899).

The last three species appear to be distinct; they differ in the type of disk plates—usually swollen and not flat.

The other two species, however, differ only by the arrangement or number of arm spines, in all other respects they appear to be very similar to *O. irrorata*. I propose to reduce them to subspecies of *O. irrorata*, because number of arm spines or their arrangement on its own does not appear to be a specific character.

*O. irrorata concreta* can be recognised by the arrangement of the arm spines: the dorsalmost spine is well separated from the two ventrally placed ones. This feature appears to be constant over a wide range of sizes and geographical areas.

*O. irrorata loveni* is characterised by having 5— arm spines, also the disk is covered with small plates and the primary plates are well separated. Madsen (1956) pointed out that this latter character appeared to be just one extreme of variation found in *O. irrorata*. Certainly some of the specimens identified by Lyman (1878, 1882) as *O. loveni* are *O. irrorata irrorata* having small disk plates but only 3 arm spines.

*O. irrorata polyacantha* Mortensen, 1933a is maintained as a subspecies characterised by having 8–9 arm spines.

*O. irrorata irrorata* can be distinguished by having only 3 arm spines which are equally spaced and situated on the ventral part of the arm or the dorsalmost one is slightly separated and situated more dorsally.

An examination of the Atlantic specimens nominally referred to *O. irrorata* revealed that there were in fact two species *O. irrorata irrorata* and a new species *Ophiura scomba*. The latter can be distinguished by its swollen oral shield, the rounded proximal ventral arm plates and pointed proximal oral papillae. *O. scomba* also appears to be found at slightly shallower depths in the NE Atlantic 1595–2240 m although there is one record of it from 4406 m in the Bay of Biscay.

*Ophiura (Ophiuroglypha) irrorata irrorata* (Lyman, 1878)

Figs 46, 47

*Ophioglypha irrorata* Lyman, 1878: 73; 1882: 47; Koehler, 1896a: 67; 1896c: 241; Koehler, 1914: 18.

*Ophioglypha grandis* Verrill, 1894: 293.

*Ophioglypha involuta* Koehler, 1898: 61–63.

*Ophioglypha tumulosa* Lütken & Mortensen, 1899: 120.

*Ophioglypha integra* Koehler, 1908: 248.

*Ophioglypha figurata* Koehler, 1908: 251.

*Ophiura irrorata*: H. L. Clark, 1911: 62; 1915: 320; Matsumoto, 1917: 227; Grieg, 1921: 32; Koehler, 1922: 380; H. L. Clark, 1923: 358–359; Mortensen, 1927: 235; Hertz, 1927a: 86; Grieg, 1932: 32–33; Madsen, 1955: 11; 1956: 26; Baranova, 1957: 207; Belyaev, 1972: 5–20.

*Homalophiura irrorata*: Koehler, 1922b: 55.

*Ophiuroglypha irrorata*: Hertz, 1927: 86–87; Pawson, 1969: 52–54.

*Ophiura (Ophiuroglypha) irrorata*: Mortensen, 1933a: 86–87; A. M. Clark & Courtman-Stock, 1976: 197.

**MATERIAL STUDIED.** BMNH: HMS *Challenger*. Stn 143, 36°48'S: 19°24'E. 3475 m. HOLOTYPE; HMS *Challenger*. Stn 164, 34°13'S: 151°38'E. 738 m; HMS *Challenger*, Stn 160, 42°42'S: 134°10'E. 4680 m (as *O. loveni*); John Murray Expedition: Stn 62, Northern Arabian Sea, 1893 m, 5 specimens; Stn 135, Maldive Area, 2727 m, 1 specimen; Stn 26, Gulf of Aden, 2312 m, 35 specimens.

**COB:** BIOGAS, Stn 3: CP04, 3850 m, 1 specimen. BIOGAS, Stn 5: CV34, 4406 m.

**IOS:** *Discovery* Investigations: Stn 8511/1, 41°54.9'N: 11°15.7'W, 2384–2399 m, 1 specimen; Stn 8521/6, 20°47.9'N: 18°23.4'W, 3064–3070 m, 1 specimen; Stn 9042, 45°15.0'N: 11°22.0'W, 1660–1541 m, 2 specimens.

**RSM:** 1921 143/1233, *Scotia* Stn 313, 62°10'S: 41°20'W, 3195 m. HOLOTYPE of *Ophioglypha figurata* Koehler, 1908; 1921 143/1231, *Scotia* Stn 313, 62°10'S: 41°20'W, 3195 m. 2 SYNTYPES of *Ophioglypha integra*; 1921 143/1231, Stn 313, 2 SYNTYPES of *O. integra*.

The disk is pentagonal, flat and covered with small plates amongst which the centrodorsal and primary plates are often conspicuous; diameter up to 30 mm. The radial shields are small, longer than broad, triangular or teardrop shaped, less than a quarter of the disk radius in length. The arm combs are just visible, below the radial shields; arm comb spinelets block-like and only an outer comb appears to be present.

There are 1–4 apical papillae flanked on either side by up to 6–7 continuous block-like oral papillae, often, particularly in larger specimens, there are supernumerary papillae which lie dorsal the oral papillae, when looking at the ventral side. The second oral tentacle pore is large and long not opening into the mouth slit, with up to 8 or 9 block-like tentacle scales on each edge. The adoral shields are long and narrow about 4 times as long as broad. The oral shield is approximately pentagonal, extending less than half way to the disk edge. The genital slits are edged with contiguous block-like papillae.



The arms are 4–6 times the disk diameter, rounded and not high. The dorsal arm plates are fan shaped in small specimens becoming broad and rectangular in large ones, and contiguous at least on proximal joints. The first two ventral arm plates are approximately hexagonal the subsequent plates are more pentagonal with an obtuse proximal angle, distally diverging lateral edges and a convex distal edge, further out on the arm they become broader than long and more rectangular; only the first three plates are contiguous. The proximal tentacle pores are large, armed with up to 8 rounded tentacle scales on each edge, the distalmost scale of the inner edge is enlarged blocking off the pore, it reaches such a size that it can be mistaken for a supplementary ventral arm plate. This enlarged tentacle scale is found on most pores except perhaps the distalmost ones. There are three short, pointed arm spines situated on the ventral part of the arm or with one slightly separated and situated more dorsally than the others; on distal arm segments the middle spine may be transformed into a small hook.

**REMARKS.** *O. irrorata* closely resembles *O. mundata* and *O. irrorata loveni* (Fig. 48). It can be distinguished from the former by the enlarged distal tentacle scale. The only feature which appears to separate it from *O. loveni* is the scaling of the disk, *O. irrorata loveni* having a disk covered with smaller plates than *O. irrorata* of the same size. Otherwise they appear to be very similar, a fact which Madsen (1956) noted suggesting that they may be conspecific. Mortensen (1933a) described a new variety of *O. irrorata*; *O. irrorata polyacantha* for two specimens collected by the *Ingolf* which had 9 arm spines evenly spaced on the lateral arm plate instead of the normal 3 arm spines.

**DISTRIBUTION.** *O. irrorata irrorata* has been recorded from the Caribbean Sea, Atlantic, Indian, Southern and Pacific Oceans with a bathymetric range of 403–5870 m. In the North Atlantic it has been recorded from off Cape Cod and SW Iceland in the west and from the Bay of Biscay south to off North Africa, in the east.

*Ophiura (Ophiuroglypha) irrorata polyacantha* Mortensen, 1933a

Fig. 47

*Ophiura (Ophiuroglypha) irrorata* var. *polyacantha* Mortensen, 1933a: 87–88.

*Homalophiura multispina* Cherbonnier & Sibuet, 1972: 1379–1382.

**MATERIAL STUDIED.** MNHN: Noratlante P43–B7 106, 58°30'N: 53°04.2'W, 3365 m. HOLOTYPE of *Homalophiura multispina*.

**BMNH:** HMS *Challenger*, Stn 158, SE Indian Ocean, 3290 m, 1 specimen originally described as *O. loveni*?

The disk is round to subpentagonal, covered with relatively large plates amongst which the larger primary plates are usually distinct although separated from one another by numerous smaller plates; diameter up to 23.5 mm. The radial shields are rounded, longer than or as long as broad, well separated, length less than a quarter the disk radius. The arm combs are just visible below the radial shields and comprise a single row of block-like spinelets.

There are 1–3 apical papillae flanked on either side by 6 or more contiguous block-like oral papillae which are often irregularly arranged. The second oral tentacle pore is large and runs to the edge of the mouth slit where it usually lies above the distal oral papilla although it can appear that the tentacle scales form a continuous series with the oral papillae. There are 7–8 rounded tentacle scales on each side with the distalmost tentacle scale much larger than the others. The adoral shields are narrow; indented in the region of the oral tentacle pore. The oral shield is rounded with an obtuse proximal angle. The genital papillae are block-like merging with the arm comb spinelets.

The arms are slightly high. The dorsal arm plates are wider than long, rectangular to trapezoidal, contiguous proximally; the proximal plates are irregular in shape and overlap each other obliquely. The first ventral arm plate is pentagonal or rhombic, the next 4–5 plates are rounded hexagonal and contiguous becoming slightly rhombic and separated. The tentacle pores are well developed proximally and armed with rounded tentacle scales the distalmost of which is the largest, resembling a supplementary ventral arm plate; the scales number as follows; A.P.1: L8–9, V6; A.P.2: L8–9, V5; A.P.3: L7, V4; A.P.4: L5, V3; A.P.5: L2–3, V1; A.P.6: 2–3, L1; A.P.7–8: L1, V1; A.P.8+: L0, V0. There are 9 short pointed arm spines proximally, 4–5 distally of which the middle one is transformed into a small hook.

**REMARKS.** In many characters, with the main exception of the number of arm spines, *H. multispina* was similar to specimens of *Ophiura irrorata polyacantha*. The holotype of *H.*

*multispina* closely resembles the description and figures given by Mortensen (19332a) for *O. irrorata polyacantha* and, therefore, it was concluded that they are consubspecific.

**DISTRIBUTION.** *O. irrorata polyacantha* has been recorded from the Labrador Basin in the NW Atlantic at depths of 3051–3366 m.

***Ophiura (Ophiuroglypha) irrorata concreta* (Koehler, 1901b)**

Fig. 47

*Ophiuroglypha concreta* Koehler, 1901b: 228; 1906: 7; 1907: 261; 1909: 148–149.

*Cphiura concreta*: H. L. CLark, 1915: 324; Mortensen, 1927: 235; Madsen, 1951: 116.

**MATERIAL STUDIED.** **MOM:** *Princesse Alice* 1901, Stn 1182, 14°47'N: 24°31'45"W, 2478 m, HOLOTYPE.

**BMNH:** *C.S. Monarch*, 47°32'N: 8°43'W, 2250 m, 1 specimen.

**SAM:** No. 22036 A 193, 33°49'S: 16°30'E, 2743 m, 4 specimens, 2096 19317, 33°50'S: 16°30'E, 2617 m, 2 specimens.

The disk is pentagonal, covered with relatively large plates amongst which the centrodorsal and primary radial plates are usually distinct although in some large specimens only the centrodorsal can be distinguished; disk diameter up to 20 mm. The radial shields are small, teardrop shaped, longer than broad and usually separated from one another by a row of large plates; they extend to about a third of the disk radius in length. The arm comb consists of a single row of contiguous block-like spinelets.

There are one to two pointed apical papillae flanked on each side by 6–7 oral papillae which are pointed proximally becoming rectangular and block-like distally. The second oral tentacle pore is large and opens into the mouth slit via a furrow. It is flanked on each side by 7 block-like tentacle scales which in some specimens form a continuous series with the oral papillae, while in others it lies above the distalmost oral papillae. The adoral shields are long and narrow indented distally adjacent to the second oral tentacle pore. The oral shield is pentagonal and as broad as long. The genital slits are edged with contiguous block-like papillae.

The arms are slightly ridged, about 3–4 times the disk diameter. The dorsal arm plates are approximately hexagonal, broader than long proximally becoming rectangular and longer than broad distally; they are contiguous along most of the arm. The first ventral arm plate is rounded, pentagonal, the second more rectangular with subsequent ones axe shaped; only the first 3–4 are contiguous. Proximal tentacle pores are large and armed with block-like tentacle scales; the distalmost scale on the inner edge is enlarged and blocking off the pore, it resembles a supplementary ventral arm plate. The tentacle scales number as follows: A.P.1: L5–6, V7; A.P.2: L6, V5–6; A.P.3: L5, V4; A.P.4: L5, V2–3; A.P.5: L3–4, V1–2; A.P.6: L3–4, V0–1; A.P.7: L3, V0–1; A.P.8–10: L3, V0; A.P.11+: L1, V0 (for large specimen  $dd \geq 15$  mm). There are 3 short rounded arm spines; the dorsalmost one is distinctly separated from the other two.

**REMARKS.** The character which distinguishes *O. irrorata concreta* is the arrangement of the arm spines. This feature is remarkably consistent over a wide geographical range.

**DISTRIBUTION.** *O. concreta* has been recorded from the Bay of Biscay, off the Cape Verde Is, and off South Africa at depths of 2250–2743 m.

***Ophiura (Ophiura) scomba* sp. nov**

Figs 46 & 56a–d

*Ophiura irrorata*: Gage *et al.*, 1983: 297–298 [non *O. irrorata* Lyman, 1878].

**MATERIAL STUDIED.** **HOLOTYPE:** **SMBA:** RRS *Challenger II* AT 254, 58°26'N: 12°35'W, 1595 m.

**PARATYPES:** **SMBA:** AT 151, 57°21'N: 10°22'W, 2175 m, 2 specimens; AT 175, 57°19'N: 10°16'W, 2220 m, 1 specimen, AT 191, 56°00'N: 13°58'W, 2190 m, 59 specimens; AT 192, 57°21'N: 12°02'W, 1862 m, 220 specimens.

**COB:** BIOGAS Stn 1: CP01, 2245 m, 4 specimens; CP27, 1920 m, 1 specimen.

BIOGAS Stn 5: CV34, 4406 m, 1 specimen.

BIOGAS Stn 6: DS49, 1845 m, 1 specimen; CV16, 1909 m, 7 specimens; CP24, 1995 m, 1 specimen; CP25, 1894 m, 5 specimens.

**IOS:** *Discovery* Investigations, Stn 9029, 31°33.4'N: 11°04.8'W, 1886–1835 m.

The disk is pentagonal, flat and covered with large plates amongst which the centrodorsal and primary plates are usually distinctive; diameter up to 17 mm, the holotype has a d.d. of 13 mm. The radial shields are

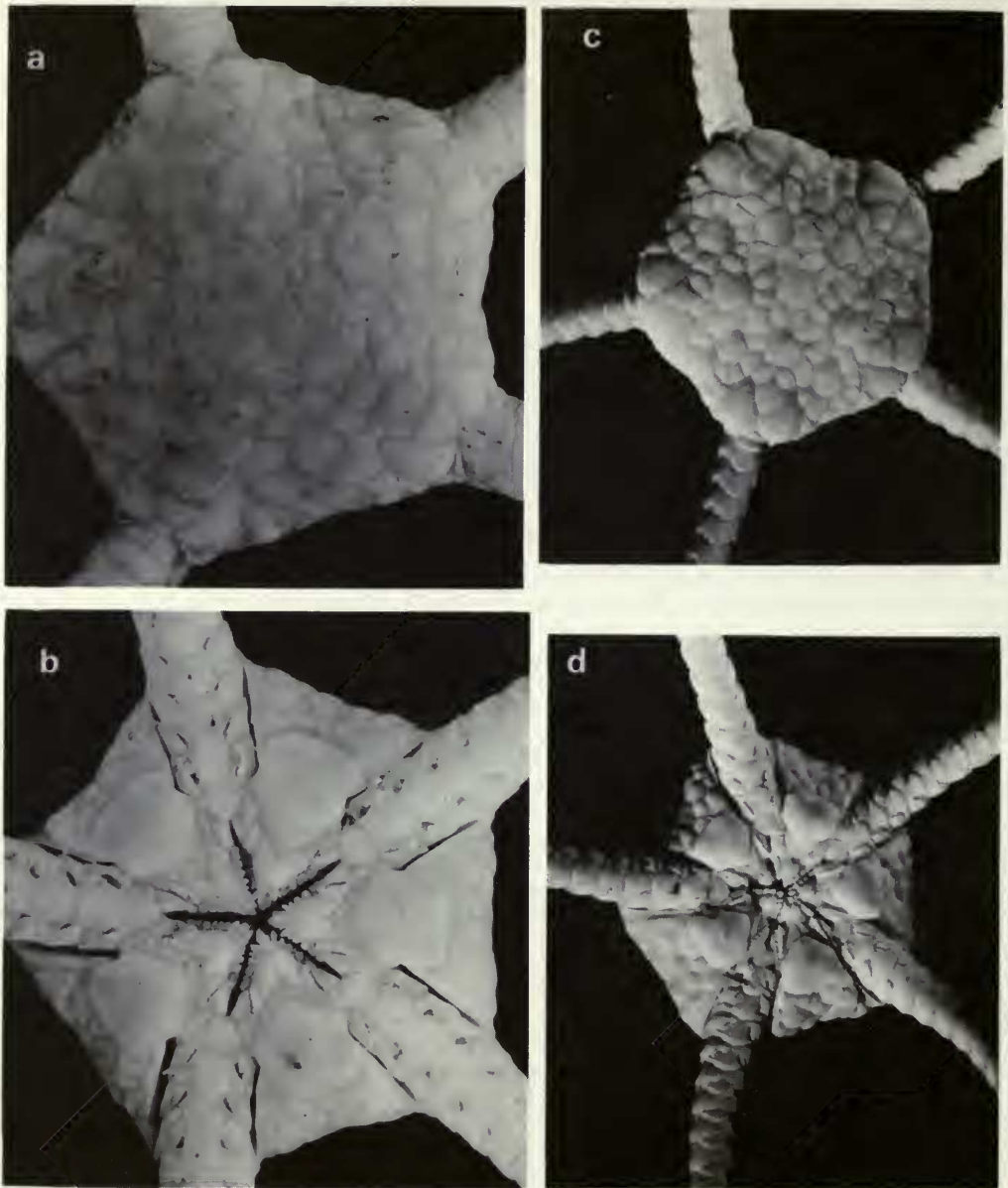


Fig. 56 Ophiuridae: Ophiurinae. a-d *Ophiura scomba* sp. nov.: (a) dorsal; (b) ventral view of holotype, d.d = 13 mm; (c) dorsal; (d) ventral view of paratype, d.d = 8.5 mm.



small, pear-shaped longer than broad, less than a quarter of the disk radius in length. The arm combs lie below the radial shields; the spinelets are block-like, contiguous and only an outer comb appears to be present.

There are 1–3 pointed apical papillae, usually one in smaller specimens, flanked by 5–6 oral papillae. The proximal oral papillae are pointed, distally they become block-like. The second oral tentacle pore arises outside the mouth slit; it is large with up to 7 contiguous block-like tentacle scales on each edge. The adoral shields are long and partially overlaid by the oral shield. The oral shield is usually pentagonal and as broad as long or slightly longer, swollen and stands out conspicuously.

The arms are 2–3 times the disk diameter. The dorsal arm plates proximally are broader than long and contiguous, distally they are longer than broad and fan shaped usually separated. The first ventral arm plate is approximately pentagonal with an indented proximal angle. Subsequent plates are trapezoidal with a very distinct convex distal edge. The first 2–5 ventral arm plates are contiguous, the number depends on the size of the specimen. The proximal tentacle pores are large and armed with rounded block-like tentacle scales, there is a large tentacle scale distally which blocks off the pore and resembles a supplementary ventral arm plate; the tentacle scales number as follows: A.P.1: L3–5, V3–4; A.P.2: L5–6, V2–5; A.P.3: L3–4, V1–3; A.P.4: L2–4, V1–3; A.P.5: L2–3, V0–2; A.P.6–7: L1–3, V0–1. There are 3 arm spines situated towards the ventral portion of the lateral arm plate.

REMARKS. For comparison with *O. irrorata* see the opening remarks.

DISTRIBUTION. *O. scomba* has been recorded from the NE Atlantic from the Rockall Trough south to off North Africa (Morocco) at depths of 1595–4406 m.

The holotype and paratype material is deposited in the BMNH and paratype material is deposited in the Dunstaffnage Marine Research Laboratory, Oban; COB, Brest; IOS, Wormley and the MNHN Paris.

DERIVATION OF NAME. The specific name *scomba* is derived from the initials of the SCottish Marine Biological Association.

### *Ophiura (Ophiura) mundata* (Koehler, 1906)

Fig. 48

*Ophioglypha mundata* Koehler, 1906: 10–11; 1907: 257; 1909: 153.

*Ophiura mundata* Mortensen, 1933a: 88–89.

*Ophiura irrorata* Mortensen, 1927: 237. [non *Ophiura irrorata* (Lyman, 1878)].

MATERIAL STUDIED. COB: BIOGAS Stn 2, CV40, 2860 m, 1 specimen.

IOS: *Discovery* Investigations: Stn 8511/1, 41°55'N: 11°15'W, 2399–2384 m, 2 specimens; Stn 8512/4, 42°15'N: 11°36'W, 2281–2245 m, 1 specimen.

The disk is round to subpentagonal, covered with large plates amongst which the centrodorsal and sometimes the primary radial plates are distinguishable by their larger size; disk diameter up to 8 mm. The radial shields are longer than broad, just over a quarter the disk radius in length, contiguous distally. There is a single row of block-like contiguous arm comb spinelets opposite each side of the arms.

There is one, sometimes two, pointed apical papillae flanked on each side by 4–6 oral papillae, the proximal ones are pointed but the rest are block-like and contiguous. The second oral tentacle pore opens away from the mouth slit and is flanked by 3–5 block-like papillae on each side. The adoral shields are long and narrow. The oral shields are pentagonal, as long as broad, extending over about half of the interradiar area in length. The genital papillae are block-like and contiguous, merging with the arm comb spinelets.

The arms are approximately 4 times the disk diameter and round. The dorsal arm plates are slightly fan shaped, often indented laterally; only the first 3–5 are contiguous. The first ventral arm plate is hexagonal, subsequent plates are wider than long and have an obtuse proximal angle and a convex distal edge; only the first two, sometimes the third and fourth depending on the size of the specimen, are contiguous. The tentacle pores are large and conspicuous only on the first 3–4 arm segments, and are armed with rounded tentacle scales and number as follows: A.P.1: L3–5, V3–5; A.P.2: L2–4, V1–4; A.P.3: L2–4, V0–2; A.P.4: L2–3, V0–1; A.P.5+: L1–2, V0.

There is no enlarged distal tentacle scale as in *O. irrorata*. There are three short pointed arm spines equally spaced or sometimes the dorsalmost spine is closer to the dorsal side and slightly distanced from the other spines.

REMARKS. This species resembles *O. irrorata* but differs primarily because it lacks the enlarged distal tentacle scale. The dorsal scaling of the disk is coarser than in *O. irrorata*. *O. concreta* could also be confused with *O. mundata*; here the main difference lies in arrangement of the arm spines—in *O. mundata* the spines are equally spaced while in *O. concreta* they are grouped together towards the ventral side of the arm. It also closely resembles *Amphiophiura saurura* and further study is needed to determine their status.

DISTRIBUTION. *O. mundata* has been recorded from the Labrador Basin, SW of Iceland, from the Bay of Biscay, off Portugal south to the Azores with a bathymetric range of 2043–4315 m.

*Ophiopleura inermis* (Lyman, 1878)

Fig. 48

*Ophioglypha inermis* Lyman, 1878: 95–96; 1882: 71–72; Koehler, 1909: 142.

*Ophioglypha aurantiaca* Verrill, 1882: 141; Lyman, 1883: 240; Hoyle, 1884: 717.

*Ophiopleura aurantiaca* Verrill, 1882: 248; Mortensen, 1927: 251–252; 1933a: 93–94.

*Ophiura inermis* H. L. Clark, 1915: 319.

*Ophiopleura inermis* Gage *et al.*, 1983: 295.

MATERIAL STUDIED. **BMNH:** HMS *Challenger* Stn off Tristan d'Acunha, HOLOTYPE & 2 PARATYPES; *Triton* Faroe Channel, 944 m, 2 specimens; *Triton* Wyville Thomson Ridge, 1015 m, 5 specimens.

**SMBA:** RRS *Challenger II*: Stn ES20, 56°46'N: 09°17'W, 1271 m, 1 specimen; Stn ES99, 60°00'N: 05°57'W, 1040m, 1 specimen.

The disk is round to subpentagonal, covered with small thin imbricating plates, often partially obscured by thickened skin; disk diameter usually up to 18 mm, although Koehler (1909) reports a specimen with disk diameter of 40 mm. The radial shields are small, rounded and separated from one another. Arm combs are not present.

The jaws are wider than long. There is one large, rounded apical papilla flanked on each side by 6–7 small rounded or sometimes pointed oral papillae which often form a continuous series with the tentacle scales of the second oral tentacle pore. The second oral tentacle pore emerges via a furrow into the mouth slit and is armed with 4–5 small rounded tentacle scales. The adoral shields are often large, longer than broad and slightly flared distally. The oral shield is wider than long, arrow shaped to rounded pentagonal. The genital slits reach to the edge of the disk and are lined with rounded papillae.

The arms are about 3–4 times the disk diameter. The dorsal arm plates are wider than long, rectangular and contiguous over most of the arm; proximally the first four may not meet and there is a conspicuous naked area. The first ventral arm plate is round pentagonal in shape, the second hexagonal and subsequent plates have a produced proximal angle and a convex distal edge; only the first four are contiguous. Only the tentacle pores of the first two segments are conspicuous and armed with 2–3 tentacle scales; the following pores are armed with 2, reducing distally to one large rounded scale. There are 3 arm spines, the dorsalmost one is the largest approximately equal in length to 1–2 arm segments, and flat with a rounded tip; the ventralmost spine is quite small resembling an enlarged tentacle scale.

REMARKS. *O. inermis* can be distinguished from *O. borealis* by the following characters: 1. lack of distinct primary plates on the disk; 2. the shape of the jaw and the oral papillae; 3. genital slits which extend to the edge of the disk; 4. long and quite narrow adoral shields; 5. the shape of the arm spines particularly the long dorsalmost one.

DISTRIBUTION. This species has been recorded from both sides of the N. Atlantic; in the west off Martha's Vineyard, New England north to western Greenland at depths of 150–1100 m, and in the east from the Faeroes south to the Azores at depths of 800–1740 m.

*Ophiopleura borealis* Danielssen & Koren, 1877

Fig. 49

*Ophiopleura borealis* Danielssen & Koren, 1877: 77; Levinsen, 1886: 23; Grieg, 1893: 3; Knipovitsch, 1901; Grieg, 1903: 15; Michailovskij, 1903: 530; Mortensen, 1903: 84; Koehler, 1909: 142; Grieg, 1910: 2;



Mortensen, 1913: 352; Koehler, 1924: 328; Mortensen, 1927: 249; Schorygin, 1928: 50; Grieg, 1932: 32; Mortensen, 1932: 35; 1933a: 95–96; Djakanov, 1954: 124–125; Blackler, 1957: 26–47; Stendall, 1967: 839; Gage *et al.*, 1983: 295.

*Lutkenia arctica* Duncan, 1878: 188.

*Ophiopleura arctica*: Duncan & Sladen, 1881: 55; Koehler, 1901: 101.

MATERIAL STUDIED. **BMNH**: Ernest Holt Barents Sea, 16 specimens; Dr A. Shorygin, Kara Sea, 3 specimens; Arctic Expedition 1875, Discovery Bay, 128 m. HOLOTYPE of *L. arctica* Duncan.

**SMBA**: RRS *Challenger II*, Stn ES87, 61°13'N: 01°59'W, 1050 m, 4 specimens.

The disk is subpentagonal, covered with small plates which are obscured by thickened skin and only seen in dried specimens, the primary plates can often be distinguished in such specimens; diameter up to 45 mm. The radial shields are small, rounded to teardrop shaped, longer than broad, and widely separated from one another. There are no arm combs.

The jaws appear to be as long as broad. There are 1–3 apical papillae flanked on either side by 6–8 rounded oral papillae which merge with the tentacle scales of the second oral tentacle pore. This pore emerges via a furrow into the mouth slit and is armed with 3–5 rounded tentacle scales on each side. The adoral shields are large about twice as long as broad. The oral shield is triangular to rounded pentagonal in shape. The genital slits are short about 2–3 arm segments in length and not extending to the edge of the disk; lined on both sides by small rounded papillae.

The arms are about 4–5 times the disk diameter. The dorsal arm plates are wider than long, rectangular, contiguous and arched. The first ventral arm plate is nearly rhombic the next one or two are hexagonal or nearly rectangular, subsequent plates become much longer than broad and more triangular in shape; only the first 2–3 ventral arm plates are contiguous. The proximal pores within the disk are large armed with rounded tentacles and number as follows: A.P.1–3: L3–6, V3–4; A.P.4: L2–3, V2; A.P.5: L1–2, V0; A.P.6+: L1–2, V=0. There are three short pointed arm spines.

REMARKS. The differences between *O. borealis* and *O. inermis* are dealt with under the latter.

DISTRIBUTION. *O. borealis* is an Arctic species found only in negative temperature water. It has been recorded from the Norwegian Sea as far south as the Faeroe Channel, east to the Barents, Kara and White Seas, with a bathymetric range of 10–1400 m.

### *Ophiecten hastatum* Lyman, 1878

Fig. 49

(For full synonymy and material studied see Paterson, Tyler & Gage, 1982.)

The disk is round covered with small imbricating plates amongst which the primary plates are sometimes distinct, the plates when dried are matt; diameter up to 12 mm. The radial shields are longer than broad, approximately half the disk radius in length, separated from one another. The arm combs are reduced, confined to the distal end of the genital plate, sometimes absent altogether.

There is one, sometimes two, apical papilla flanked on each side by 3–5 oral papillae, which are pointed proximally becoming contiguous and block-like distally. The second oral tentacle pore opens superficially away from mouth slit and is armed with 1 or 2 small, rounded tentacle scales on each side. The adoral shields are longer than broad. The oral shields are broader than long and pentagonal. The genital slits are conspicuous without genital papillae except sometimes at the distal end of the genital plate.

The arms are about 4–5 times the disk diameter. The dorsal arm plates are often strongly arched with a convex distal edge, contiguous at least proximally. The first ventral arm plate is pentagonal to trapezoidal, the second arm plate is broader than long sometimes contiguous with the third; subsequent plates have an obtuse proximal angle and a rounded distal edge, and are separated. The tentacle pores are open armed only with one or two small tentacle scales. There are three pointed arm spines of which the dorsalmost is the longest up to 1.5 arm segments long and twice as long as the other two arm spines.

REMARKS. *O. hastatum* can be distinguished from other deep water *Ophiecten* species by the reduced or absent arm combs and genital papillae and by the long dorsal arm spines.

DISTRIBUTION. This species has been found in the Atlantic, Southern and Pacific Oceans. In the North Atlantic it has mainly been recorded from the east from the Rockall Trough south to the Azores at depths of 1970–4700 m, but it has been recorded only from the Labrador Basin in the west at 2340–2750 m.



*Ophiocten gracilis* (G. O. Sars, 1871)

Fig. 50

(See Paterson, Tyler & Gage, 1982 for full synonymy and material studies.)

The disk is round with distinct primary plates, dorsal surface matt when dried, diameter up to 12 mm. The radial shields are longer than broad, just under half the disk radius in length, separated from one another. The arm combs are moderately well developed consisting of pointed spinelets confined to each side of the arm sometimes with one or two spinelets on the first dorsal arm plate.

There is one pointed apical papilla flanked on each side by 3–4 oral papillae which are pointed proximally becoming block-like distally; often these distal ones have secondary points. The second oral tentacle pore opens away from the mouth and is armed with 1–2 small tentacle scales. The adoral shields are longer than broad. The oral shields are broader than long pentagonal or squat arrow shaped. Only the distal portion of the genital slit is edged with spine-like papillae.

The arms are about 3–5 times the disk diameter. The dorsal arm plates are broader than long, contiguous and usually strongly arched. The first ventral arm plate is pentagonal, the second has an acute proximal angle and a convex distal edge, in subsequent plates the distal edge is also indented; all are separated. There are 3 arm spines the dorsal one is often the longest. The tentacle pores are open, armed with 1–2 small often pointed tentacle scales.

REMARKS. The confusion surrounding this species has been discussed by Paterson, Tyler & Gage (1982). *O. gracilis* can be distinguished by the shape of the oral shield, presence of genital papillae only on the distal portion of the genital plate and an arm comb of pointed spinelets at the base of the arms, not forming a fringe over the base of the arm.

DISTRIBUTION. *O. gracilis* has been recorded on both sides of the North Atlantic in the west from off the east coast of North America to Iceland and in the east from the Norwegian Sea south to the Rockall Trough. It is a bathyal species found at depths of 600–1200 m.

*Ophiocten centobi* Paterson, Tyler & Gage, 1982

Fig. 49

*Ophiocten centobi* Paterson, Tyler & Gage, 1982: 119–121.

MATERIAL STUDIED. COB: *Cymor* drague 15, 47°44'N: 8°21'W, 2420 m. HOLOTYPE & 2 PARATYPES.

The disk is round with very large conspicuous plates which are nearly contiguous but are separated by a ring of much smaller plates; diameter up to 4.5 mm. The radial shields are small less than a quarter of the disk radius, nearly twice as broad as long and contiguous for most of their length. The arm combs form a continuous fringe over the arm base and consist of stout, pointed spinelets.

There is one pointed apical papilla flanked on each side by 3–4 oral papillae, the proximal ones are pointed, the distalmost ones block-like. The second oral tentacle pore arises superficially away from the mouth slit and is armed with 2–3 tentacle scales on each side. The adoral shields are long and narrow. The oral shield is as broad as or broader than long, pentagonal or squat arrow shaped. The genital slits are conspicuous and lined along their entire length by stout, pointed papillae.

The arms are about 3 times the disk diameter. The dorsal arm plates are fan shaped and contiguous, not strongly arched. The first ventral arm plate is pentagonal subsequent plates have an acute proximal angle and a convex distal edge; all are separated. The tentacle pores are open, each is armed with 2 relatively large tentacle scales. There are 3 long, pointed arm spines, the dorsalmost is usually the largest.

REMARKS. *O. centobi* can be distinguished by the continuous fringe of stout pointed arm comb spinelets across the base of the arms, similar genital papillae which extent the full length of the slit the large disk plates and the small contiguous radial shields.

DISTRIBUTION. This species has been recorded only from the type locality in the Bay of Biscay at 2420 m.

The *Amphiophiura bullata* complex

This complex comprises the species *A. bullata bullata*, *A. bullata pacifica*, *A. convexa* and *A. vitjazi*, taxa which have the same organisation of the ventral and oral plates but which differ

mainly in the plating of the dorsal surface of the disk. A review of other *Amphiophiura* species suggests that a character such as disk plating is often subject to considerable variation.

A study of the species in question, using type specimens in the BMNH and other specimens from the Vema and Demeraby collections, shows that they appear to lie on a cline of variation. *A. convexa* has a disk dominated by the primaries with few secondary plates; in *A. bullata bullata* the primaries are smaller and usually separate often by many small plates. *A. bullata pacifica* appears to have a disk with more secondary plates and finally *A. vitjazi* has a disk of small plates, often slightly obscured by thickened skin, and the primaries least conspicuous. The thickening of skin could be the result of decreasing plate size.

*A. bullata* and *A. convexa* have been considered to be conspecific by several authors (e.g. Cherbonnier & Sibuet, 1972, Gage *et al.*, 1983 and A. M. Clark personal communication). But small specimens of *A. convexa* generally have fewer plates on the disk, large contiguous primary plates with few small supplementary ones whereas a comparison of type specimens of *A. bullata* of similar size, dd c. 5 mm reveals that the primary plates are not always contiguous and there are often many supplementary plates even by a disk diameter of 7 mm. In larger specimens (dd. of 15 mm) it becomes difficult to separate the two as *A. convexa* may have many supplementary plates and the primaries are not always contiguous.

The range of variation described by Litvinova (1972) for *A. bullata pacifica* appears to encompass the range of disk plate patterns described for *A. bullata bullata* to *A. vitjazi*. This suggests that the character of the disk plating could be polymorphic. I therefore propose to reduce *A. convexa* and *A. vitjazi* to the rank of subspecies of *A. bullata* together with *A. bullata pacifica*.

*Amphiophiura bullata bullata* (Wyville Thomson, 1877)

Fig. 51

*Ophioglypha bullata* Wyville Thomson, 1877: 399; Lyman, 1878: 83–84; 1882: 57–58; Verrill, 1885b: 543; 1894: 295; Koehler, 1906: 6; 1907: 259; 1908: 598.

*Ophioglypha abdita* Koehler, 1901b: 225; 1909: 145–147.

*Amphiophiura bullata* Matsumoto, 1915: 77; Mortensen, 1927: 231; Madsen, 1951: 107–108; Schoener, 1967: 653–655; Litvinova, 1971: 305; Cherbonnier & Sibuet, 1972: 1376.

**MATERIAL STUDIED.** BMNH: HMS *Challenger*, Stn 61, 34°54'N: 56°38'W, 5212 m. HOLOTYPE & PARATYPES; Stn 45, 38°34'N: 72°10'W, 2268 m, specimen; Stn 54, 34°51'N: 63°59'W 4846 m, specimens.

**COB:** BIOGAS Stn, CP05, 3850 m, 2 specimens.

The disk is round to subpentagonal, high, sometimes domed; covered with two sizes of plate, large primaries and often numerous smaller plates. The primaries may be contiguous and separated from the radial shields and disk edge by the smaller plates or they may be separated and encircled by these smaller plates. The disk diameter reaches 16 mm. The radial shields are usually longer than broad but sometimes as broad as long, just over a quarter of the disk diameter in length, often contiguous. The arm combs are comprised of distinct rounded squarish spinelets, the comb is situated opposite the base of the arms. The plates of the disk and arms are textured by what appears to be small glassy beads or crystal bodies in the matrix of the plates.

There are 1–3 large pointed papillae at the apex of the jaw which are sometimes difficult to distinguish from the teeth and the first oral papillae; flanking them on each side are up to 8 small rounded or slightly pointed oral papillae, which decrease in size distally. The second oral tentacle pore opens superficially away from the mouth slit and is armed with 3–4 scales on the outer-first ventral plate-edge, 1–3 on the adoral shield edge. The adoral shields are short, broader than or as broad as long. The oral shield is large occupying most of the interradiation space, approximately pentagonal with an obtuse proximal angle and lateral edges which diverge towards the straight or slightly convex distal edge. The genital slits extend to the edge of the disk and are lined by contiguous block-like papillae.

The arms are short, only about twice the disk diameter in length, and high. The dorsal arm plates are domed and hexagonal, usually wider than long but sometimes as long as broad, contiguous along the proximal arm. The first ventral arm plate is pentagonal, subsequent plate square, contiguous along the proximal part of the arm. Tentacle pores are large proximally, armed with rounded or elongated scales which number as follows: A.P.1–5; L3–5, V1–2; A.P.5+: L2–3, V0–1. There are 3 very short, pointed, equally spaced arm spines.



REMARKS. *A. bullata bullata* has variable disk plating patterns, ranging from the disk dominated by the contiguous primaries which are usually surrounded by many smaller plates although the number of small plates varies to the primary plates being separated from one another with the disk comprising of mostly small plates. This degree of variability may well encompass *A. bullata pacifica* but not having examined any material from the Pacific, it is not possible to comment further.

Schoener (1967) and Litvinova (1971) both comment that it is difficult to separate juvenile individuals of *A. bullata bullata* and *A. bullata convexa*.

DISTRIBUTION. This subspecies has only been recorded from the North Atlantic; in west from off Delaware, Bermuda and near the Mid-Atlantic Ridge at depths of 2268–5320 m, in the east from the Bay of Biscay to off Sierra Leone at depths of 4165–5600 m.

*Amphiophiura bullata convexa* (Lyman, 1878)

Fig. 51

*Ophioglypha convexa* Lyman, 1878: 84; 1882: 58; Koehler, 1907: 293; 1908: 149; 1909: 142; 1914: 12.

*Amphiophiura convexa* Matsumoto, 1915: 77; 1917: 263; Hertz, 1927a: 75; H. L. Clark, 1939: 107; Litvinova, 1971: 302–303; Litvinova & Sokolova, 1971: 284; Cherbonnier & Sibuet, 1972: 1376; Gage *et al.*, 1983: 295–296; Bartsch, 1983: 16.

MATERIAL STUDIED. BMNH: HMS *Challenger* Stn 241, E of Japan, 4206 m. HOLOTYPE & PARATYPE; HMS *Challenger* Stn 246, Hawaii, 3749 m, 2 specimens; HMS *Challenger* Stn 346, 2°42'S: 178°E, 3770 m, 1 specimen; U.S. Fish Comm. 68°53'N: 89°23'W off Martha's Vineyard, 3116 m, 1 specimen; J. Murray Exped. Stn 171, Central part of Arabian Sea, 2 specimens.

COB: BIOGAS Stn 4, CV30, 4518 m, 2 specimens; CV35, 4721 m, 3 specimens; CP15, 4715 m, 2 specimens; CP16, 4825 m, 14 specimens; CP17, 4706 m, 21 specimens; CP18, 4721 m, 2 specimens. BIOGAS Stn 6, DS86, 1950 m, 1 specimen.

INCAL: CP12, 46°00'5N: 10°18'3W, 4796 m, 14 specimens; CP13, 46°02'1N: 10°14'8W, 4800 m, 17 specimens; DS13, 46°01'9N: 10°17'9W, 4822 m, 2 specimens; ØS03, 46°02'5N: 10°19'5W, 4798 m, 1 specimen; ØS04, 46°03'9N: 10°12'8W, 4796 m; WS05, 46°03N: 10°15'7W, 4804 m, 5 specimens; WS09, 47°28'8N: 9°34'0W, 4277 m, 2 specimens.

BIOVEMA: CP01, 10°58'3N: 45°14'3W, 10°58'3N: 45°13'W, 5100 m, 1 specimen; CP02, 10°59'0N: 45°15'0W—11°00'3N: 45°12'9W, 5073 m, 5 specimens; CP04, 10°45'97N: 42°40'25W—10°45'90N: 42°39'35W, 5100 m, 1 specimen; CP05, 10°46'23N: 42°40'41W—10°46'36N: 42°39'75W, 5100 m, 2 specimens.

DEMERABY, Stn 12: CP07 10°23.17'N: 46°45.34'W—10°23.53'N: 46°46.13'W, 4850 m, 2 specimens; CP08, 10°25.13'N: 46°55.93'W—10°25.66'N: 46°45.93'W, 4850 m, 5 specimens; CP09, 10°23.65'N: 46°47.22'W—10°23.86'N: 46°48.12'W, 4850 m, 11 specimens; CP10, 10°24.36'N: 46°44.68'W—10°24.93'N: 46°45.28'W, 4850 m, 5 specimens; CP11, 10°23.16'N: 46°46.23'W—10°23.83'N: 46°47.08'W, 4850 m, 2 specimens; CP12, 10°21.11'N: 46°47.71'W—10°21.63'N: 46°48.13'W, 4830 m, 3 specimens; CP13, 10°24.16'N: 46°45.10'W—10°24.74'N: 46°45.68'W, 4830 m, 3 specimens; CP14, 10°24.32'N: 46°46.02'W—10°25.14'N: 46°46.26'W, 4830 m, 2 specimens.

The disk is round to subpentagonal, high sometimes domed covered with a few large plates, usually the primary plates and large secondaries; diameter up to 15 mm. The primary plates nearly always contiguous, the secondary plates are only slightly smaller than the primaries. Only in larger specimens are smaller plates developed, usually around the periphery of the primaries and associated secondary plates. Such specimens are often difficult to tell apart from *A. bullata bullata*. The radial shields are slightly longer than broad, just over a quarter the disk radius in length; usually contiguous over most of their length except in some of the larger specimens where they are separated distally by a wedge of plates.

Other features are as described for *A. bullata bullata*.

REMARKS. The disk plating patterns of this subspecies are quite constant in that the primary plates are usually contiguous and that the overall number of plates remains low until quite a large size is reached i.e. dd 12–13 mm. Litvinova (1971) reports that *A. bullata convexa* can be distinguished from *A. bullata bullata* in that the radial shields of *convexa* are usually contiguous irrespective of disk size while those of *bullata* are contiguous usually only in small specimens and are progressively separated with increasing size. Certainly from the specimens examined this



would appear to be true but in addition separation of the radial shields can also be linked to the development of small secondary plates. Specimens of *bullata* with separated primary plates and numerous small plates covering the disk usually have the radial shields separated. But specimens with contiguous or nearly contiguous primaries usually do not have so many secondaries and the radial shields are usually contiguous or only just separated. This feature does not appear to be linked with size.

**DISTRIBUTION.** *A. bullata convexa* has been recorded on both sides of the North Atlantic; in the west from the Labrador Basin off the coast of New England and south in the Demerara Abyssal Plain off northern South America at depths of 3126–4800 m; in the east from the Rockall Trough, Bay of Biscay, off the Azores and Vema Fracture zone at depth of 1997–5100 m. It has also been recorded from the Indian and Pacific Oceans.

*Amphiophiura bullata vitjazi* Litvinova, 1971

Fig. 51

*Amphiophiura vitjazi* Litvinova, 1971: 300–301; Litvinova & Sokolova, 1971: 287.

**MATERIAL STUDIED.** **COB:** BIOVEMA DS09, 11°36'4"N: 32°51'8"W—11°37'1"N: 32°51'3"W, 5875 m, 49 specimens; DS11, 11°37'5"N: 32°53'8"W—11°37'8"N: 32°52'8"W, 5867 m, 108 specimens; CP06 11°34'2"N: 32°53'5"W—11°34'1"N: 32°52'8"W, 5880 m, 422 specimens.

The disk is round to subpentagonal, high, not usually domed, covered with many small plates amongst which the rounded primary plates are usually distinct, being slightly larger; diameter up to 11 mm. The plate edges are often indistinct and covered with thickened skin which encircles each plate. The primary plates are usually separate and in some specimens may be indistinct. The radial shields are longer than broad occasionally broader or as broad as long, contiguous only distally, if at all, separated by a wedge of plates; just over a quarter to nearly a half of the disk radius in length.

Ventral and arm characters as in *A. bullata bullata*.

**REMARKS.** Litvinova (1971) separated this species from *A. bullata* by the disk plating, the small size of the plates and the rounded nature and small size of the primary plates, and the adoral shield being only half as wide as the oral plate.

The character of the plates of the disk was discussed earlier. Litvinova's subspecies *A. bullata pacifica* has a similar arrangement although the plates do not appear to be encircled by thickened skin. The relative sizes of the oral plate and adoral shield appear to be variable; in specimens collected by the Biovema, which agree with Litvinova's description in all other respects, the relative widths of the two plates varies from nearly twice as wide to approximately equal. In specimens of *A. bullata convexa* the proportions also vary but not as much as twice as broad as long.

**DISTRIBUTION.** This subspecies was previously recorded from the Pacific Ocean from the Ryukyu Trench at a depth of 6810 m. Its occurrence in the North Atlantic from the Vema Fracture Zone at depths of 5100 m marks an extension of range.

*Amphiophiura metabula* H. L. Clark, 1915

Fig. 50

*Amphiophiura metabula* H. L. Clark, 1915: 311; John & A. L. Clark, 1954: 158–159.

**MATERIAL STUDIED.** **BMNH:** Blake Stn 271, off St Vincent, 1164 m. **PARATYPE;** *Rosaura* Stn 26, 17°53'N: 87°44'W, 900 m, 2 specimens; Stn 34, 12°05'N: 61°49'W, 720–800 m, 2 specimens.

The disk is round to subpentagonal, only slightly domed and covered with many large plates often with smaller ones between them; the centrodorsal and primary plates distinct; diameter up to 10 mm. The disk plates are not as heavily textured as *Amphiophiura bullata bullata* and each plate is surrounded by thin lamellar border. The oral shield and proximal ventral arm plates also have this structure while the lateral arm plates have a texture resembling *A. bullata bullata*. The radial shields are rectangular to teardrop shaped, as long as or only slightly longer than broad, contiguous for at least half their length and extending to about a quarter of the disk radius. The arm comb extends beyond the edge of the disk, comprising two rows of spinelets, an inner often obscured, row of fine pointed spinelets and an outer row of thin often blunt spinelets which become more block-like ventrally.

There are one or two large triangular apical papillae flanked on each side by 4–5 oral papillae which become progressively more block-like and elongated distally. The second oral tentacle pore is large, not quite opening into the mouth; armed with large block-like tentacle scales, 4–5 on each edge. The adoral shields are longer than broad, widening slightly towards their distal edge. The oral shields are rounded triangular with indented lateral edges. The genital slits are conspicuous fringed with block-like papillae which merge with the spinelets of the arm comb.

The arms are short about two times the disk diameter; they are not conspicuously keeled. The dorsal arm plates are fan shaped only the first four or five contiguous. The first ventral arm plate is roughly hexagonal with a broad distal edge, the other ventral arm plates are axe shaped, only the first three or four contiguous. The tentacle pores are large particularly the proximal ones and armed with large block-like tentacle scales, which number as follows: A.P.1: L4–5, V3–4; A.P.2: L3–4, V3; A.P.3: L3, V2–3; A.P.4+: L1–2, V0–1. There are 3–5 short, pointed, equal arm spines.

REMARKS. *A. metabulla* can be distinguished by the texturing of the plates, the form of the arm comb, the shape of the oral shield and the large size of the second oral tentacle pore and scales.

DISTRIBUTION. It has been recorded primarily from the West Indies and Gulf of Mexico but the *Blake* took one specimen from off South Carolina in 1164 m.

### *Amphiophiura saurura* (Verrill, 1894)

Fig. 50

*Ophioglypha saurura* Verrill, 1894: 288.

*Ophioglypha aspera* Koehler, 1898: 40.

*Amphiophiura saurura* H. L. Clark, 1915: 315; Mortensen, 1927: 231; 1933a: 89; Gage *et al.*, 1983: 296.

*Amphiophiura aspera* Mortensen, 1927: 231.

MATERIAL STUDIED. COB: BIOGAS Stn 1: CP01, 2245 m, 1 specimen; BIOGAS Stn Hz, DS14, 1560 m, 1 specimen.

SMBA: RRS *Challenger II*, ES Stn 112, 55°12'N: 15°50'W, 1900 m, 5 specimens.

The disk is round to subpentagonal; not usually high or domed; covered with many large plates amongst which the centrodorsal and primary plates are distinguishable; diameter up to 13 m. The radial shields are triangular to tear drop shaped, separated by a wedge of plates, and extend to about a quarter of the disk radius. The arm combs just project from beneath the radial shields; the arm comb spinelets are block-like.

There is one pointed apical papilla flanked on each side by 3–5 oral papillae which become progressively more block-like distally. The oral papillae appear to merge with the inner tentacle scales of the second oral tentacle pore which opens via a slit into the mouth and is armed with up to 6 contiguous block-like tentacle scales on its inner edge and 6 similarly shaped scales on its outer. The adoral shields are long and narrow slightly bowed. The oral shield is pentagonal with often an acute proximal angle, slightly convex proximal lateral edges and a straight distal edge. The genital slits run from the oral shield to the dorsal surface and are edged with block-like papillae which merge with the spinelets of the arm comb.

The arms are short, two to three times the disk diameter in length; and are rounded without a conspicuous keel so that they do not appear high. The dorsal arm plates are slightly domed, in profile the distal edge appears to be slightly raised then terminates quite abruptly, and contiguous. The first ventral arm plates is irregularly hexagonal or sometimes pentagonal, with an obtuse proximal angle and a convex distal edge, the next four plates are irregularly pentagonal with a more pronounced convex distal edge. Subsequent plates become wider than long approaching a rectangle in shape. The first three to five plates are contiguous. The proximal tentacle pores are large and conspicuous and armed with block-like tentacle scales, the number of which decreased down the arm as follows: A.P.1: L5, V4; A.P.2: L4, V4; A.P.3: L3–4, V3; A.P.4: L2–3, V3; A.P.5: L2, V2; A.P.6+: L1, V1. There are three short pointed arm spines on the ventral side of the arm.

REMARKS. *A. saurura* superficially resembles *Ophiura irrorata* or *O. mundata*, particularly smaller specimens d.d. less than 6 mm, but is distinguished by: 1. the slightly domed dorsal arm plates; 2. the shape of the oral shield; 3. the second oral tentacle pore opening into the mouth via a slit; 4. the arm spines being aligned on the ventral part of the arm.

More specifically *A. saurura* lacks the excessively developed distal tentacle scale found in *O. irrorata*.

DISTRIBUTION. *A. saurura* has been recorded from both sides of the North Atlantic Ocean; in the west from off Nantucket and Newfoundland with a bathymetric range of 844–1267 m and in the east from south of Iceland to the Bay of Biscay with a bathymetric range of 1560–2245 m.



*Stegophiura macrarthra* H. L. Clark, 1915

Fig. 52

*Ophioglypha stuwitzii*? Lyman, 1883: 242.*Ophioglypha elevata* Koehler, 1914: 16–17; [non *O. elevata* (Lyman) acc. H. L. Clark 1915].*Stegophiura macrarthra* H. L. Clark, 1915: 317–316.

MATERIAL STUDIED. MCZ: Blake Stn 321, 32°43'25"N: 77°20'30"W, 429 m, HOLOTYPE.

COB: BIOGAS Stn 1: DS64, 2156 m, 1 specimen; Stn HZ: DS 33, 2338 m 1 specimen.

IOS: Discovery Investigations: Stn 9042, 45°15'N: 11°22'W, 1662–1541 m, 23 specimens.

SMBA: RRS *Challenger II* Stn ES112, 55°12'N: 15°50'W, 1900 m, 1 specimen.

The disk is round, moderately high covered with plates amongst which the slightly larger centrodorsal and primary radial plates are distinct; diameter up to 6.5 mm. The radial shields are short, less than one quarter of the disk radius in length, broader than or as broad as long; the distal edge forms an obtuse angle; the shields are contiguous for most of their length. The arm comb consists of long pointed spinelets.

There is one, sometimes two, apical papilla flanked on each side by 4–6 contiguous, block-like papillae. The second oral tentacle pore is large, opening away from the mouth slit, armed with 2–3 large, rounded tentacle scales on each side. The adoral shields are long and narrow. The oral shields are approximately arrow shaped; the ventral portion lies above the part proximal to the genital slits. The genital slits are fringed by a row of pointed papillae.

The arms are short, at most 2–3 times the disk diameter, rounded distally. The dorsal arm plates are rectangular, slightly wider than long and contiguous, distally they become fan-shaped and separated. The first ventral arm plate is pentagonal and slightly swollen, the next four plates are contiguous and approximately rectangular, each has a distinctive keel in the midline; subsequent plates have a more convex distal edge but no keel. The proximal tentacle pores are large and distinctly swollen and armed with large rounded tentacle scales which number as follows: A.P.1: L3, V2–3; A.P.2: L3–4, V2–3; A.P.3: L2–3, V2; A.P.3–5: L3, V2–1; A.P.6+: L2, V0. There are 3–4 pointed arm spines proximally; the first three dorsalmost are evenly spaced but the fourth and ventralmost spine is situated close to the third.

REMARKS. *S. macrarthra* closely resembles *Stegophiura stuwitzii* (Lütken) it can be distinguished by the following characters: a. the shape of the oral shield which is arrow shaped with a median constriction, but more pentagonal in *S. stuwitzii*; b. the fewer and larger arm spines which are quite evenly spaced, while those of *S. stuwitzii* are smaller more number up to 6 proximally; c. the first four ventral arm plates only being swollen or keeled, while the first 10 are keeled or swollen in *S. stuwitzii*.

DISTRIBUTION. This species has been recorded from both sides of the North Atlantic; in the west off Georgia 32°43'25"N: 77°20'30"W, 419 m and in the east from the Rockall Trough south to the Bay of Biscay with a bathymetric distribution 1541–2338 m.

A review of the genus *Homalophiura* H. L. Clark, 1915

Hertz (1927b), Mortensen (1936) considered that *Homalophiura* could not be maintained as a genus distinct from *Ophiurolepis* Matsumoto, 1915, a view supported by Madsen (1969) who transferred the type species *H. inornata* to *Ophiurolepis* thus invalidating the generic name. However, the remaining species (see list below) are in need of review.

*Ophiurolepis* is characterised by poorly developed arm combs, small tentacle pores restricted to the proximal arm segments, short genital slits with rudimentary genital papillae and high more or less normally carinate arms or with sculptured dorsal arm plates. *H. inornata* and three other species which have been included in *Homalophiura* also conform to this diagnosis but the majority of *Homalophiura* species do not.

*Homalophiura* was characterised only by: the reduced arm combs and tentacle pores restricted to the proximal segments. However, H. L. Clark (1915) expanded the generic diagnosis to include all Ophiurinae with reduced development of the tentacle pores which did not otherwise conform with *Ophiurolepis* or *Ophioplinthus* Lyman, 1878.

This character is more widespread than H. L. Clark realised, particularly within the genus *Ophiura* where the tentacle pores become ill-defined distally in many species.



Based on specimens within the BMNH and descriptions of the other species—see list below—four groups emerge within *Homalophiura*:

- A. Species with short genital slits, poorly defined arm combs, high arms and small tentacle pores restricted to the proximal 2–3 arm segments i.e. *H. inornata*, *H. confragosa*—referable to *Ophiurolepis*.
- B. Species with genital slits extending to the disk edge, well developed arm combs, tentacle pores relatively large and armed with conspicuous tentacle scales, e.g. *H. divisa*, *H. nana*—referable to *Ophiura* (*Ophiura*) *sensu lato*, pending full revision of this genus.
- C. Species agreeing with those in B but also having the distalmost arm spine modified to hooks, e.g. *H. glypta* and *H. schmidtotti* referable to *Ophiura* (*Ophiuroglypha*).
- D. Species with long genital slits, poorly developed arm combs small tentacle pores restricted to the first 2–4 proximal arm segments and slightly enlarged proximal arm segments referable to a new genus *Homophiura*, defined below.

#### Assignment of species of *Homalophiura sensu extenso*

**Group A**—referrable to *Ophiurolepis*

+ *H. brucei*\* (Koehler, 1907b); + *H. confragosa* (Lyman, 1878), + *H. inornata* (Lyman, 1878), + *H. scissa* (Koehler, 1908).

**Group B**—referable to *Ophiura* (*Ophiura*)

*H. divisa* (Lütken & Mortensen, 1899), *H. flexibilis* (Koehler, 1911); *H. inflata* (Koehler, 1897); *H. madseni* (Belyaev, 1972); + *H. mimaria* (Koehler, 1908); *H. nana* (Lütken & Mortensen, 1899); *H. scutellata* (Lütken & Mortensen, 1899); + *H. violinae* Cherbonnier & Sibuet, 1972.

**Group C**—referable to *Ophiura* (*Ophiuroglypha*)

+ *H. euryplax* H. L. Clark, 1939; + *H. glypta* H. L. Clark, 1939; + *H. intorta* (Lyman, 1878); *H. schmidtotti* (Hertz, 1927); + *H. multispina* Cherbonnier & Sibuet is conspecific with *Ophiura* (*Ophiuroglypha*) *irrorata polyacantha*, see p. 124.

**Group D**—referable to *Homophiura* gen. nov.

+ *H. abyssorum* (Lyman, 1883); *H. clasta* (H. L. Clark, 1911); + *H. tessellata* (Verrill, 1894);—type species.

Fell (1961) transferred *H. partita* (Koehler, 1907b) to his new genus *Theodorina* and noted that *H. frigida* (Koehler, 1901a) may also belong in this genus.

\*+specimens examined.

#### *HOMOPHIURA* gen. nov.

The disk covered by rounded plates separated from one another by thickened skin; radial shields relatively large longer than broad; arm combs rudimentary comprised of one or two rows of rounded or slightly elongated granules; one block-like apical papilla flanked by contiguous oral papillae second oral tentacle pore arising outside the mouth slit; oral shields large and contiguous along the distal edge with a large accessory plate usually of equal width, genital slits extending to the edge of the disk lined the whole length or only distally by rounded or elongated granules; the arms relatively long rounded not high; dorsal arm plates not particularly high, often fragmented; tentacle pores small restricted to the first 3–5 arm segments armed with small pointed tentacle scales; arm spines short and pointed; proximal arm segments within the disk are swollen.

TYPE SPECIES. *Ophioglypha tessellata* Verrill, 1894.

REMARKS. Other species included are *Homalophiura abyssorum* (Lyman, 1883), *Homalophiura clasta* (H. L. Clark, 1911) and *Ophiurolepis martensi* (Studer, 1885).

*Homophiura* is related to *Ophiurolepis* and probably *Theodorina* Fell, 1961. It differs from *Ophiurolepis* mainly by the greater extent of the genital slits which reach to the edge of the disk, regular arrangement of the oral papillae, jaw plates, adoral and oral shields. The latter tend to be fragmented in *Ophiurolepis* whereas in *Homophiura* they are large undivided and abut distally a

large plate. Also the dorsal arm plates of *Homophiura* are flat, or sometimes slightly elevated, but never carinate. This character is also quite variable in *Ophiurolepis* although specimens with low dorsal arm plates tend to have short genital slits and fragmented oral frame plates, i.e. *Ophiurolepis partita*.

*Ophiurolepis gelida* is perhaps intermediate between the two genera often having relatively long genital slits although these do not quite reach the disk edge—the length is variable. *O. gelida* has carinate dorsal arm plates, fragmented oral frame plates and no single large plate distally. The oral shield features relate it more closely to *Ophiurolepis*. However, further studies are necessary to clarify the relationships between *Homophiura*, *Ophiurolepis*, *Theodoria* and *Ophioplinthus*, a task beyond the scope of this study.

*Homophiura tessellata* (Verrill, 1894) n. comb

Fig. 52

*Ophioglypha tessellata* Verrill, 1894: 290; Koehler, 1898: 37; 1909: 156.

*Homalophiura tessellata* H. L. Clark, 1915: 327; Mortensen, 1927: 232; 1933a: 91; Gage *et al.*, 1983: 295.

MATERIAL STUDIED. USNM: *Albatross* Stn 2205, 39°35'N: 71°18'W, S of Block Island, 1928 m, 3 SYNTYPES.

COB: BIOGAS Stn 1: DS17, 2103 m, 1 specimen; CP26, 2115 m, 1 specimen; CP27, 1920 m, 2 specimens. BIOGAS Stn 2: CV12, 2775 m, 14 specimens; CV26, 2822 m, 2 specimens; CV38, 2695 m, 9 specimens. BIOGAS Stn 3: CV13, 4252 m, 1 specimen. BIOGAS Stn 4: CP17, 4706 m, 1 specimen.

INCAL: Stn CP04, 56°33'2N: 11°11'3W, 2483 m, 3 specimens; Stn DS14, 47°32'6N: 9°35'7W, 4254 m, 9 specimens; Stn 15, 47°33'4N: 9°39'1W, 4211 m, 1 specimen.

IOS: *Discovery* Investigations: Stn 7711/52, 52°53.3'N: 19°52.4'W, 2734–2742 m, 1 specimen; Stn 7711/78, 53°9.8'N: 20°14.7'W, 2425–2430 m, 1 specimen; Stn 8511/2, 41°49.6'N: 11°6.0'W, 2574–2584 m, 1 specimen.

SMBA: RRS *Challenger II* Stn SWT18, 56°46'N: 09°42'W, 1809 m, 1 specimen; Stn AT144, 57°13'N: 10°20'W, 2240 m, 2 specimens; Stn AT151, 57°21'N: 10°22'W, 2175 m, 1 specimen; Stn AT154, 57°00'N: 10°22'W, 2264 m, 2 specimens.

The disk is pentagonal, sometimes high, and covered with large irregularly shaped plates amongst which it is sometimes possible to distinguish the centrodorsal and primary radial plates; each plate seems to be encircled by thin layer of skin; diameter up to 30 mm. The radial shields small just over a quarter the disk radius in length, longer than broad slightly oval, and separated. There are a number of block-like papillae visible opposite the base of each arm forming a rudimentary arm comb. These may be arranged into two rows.

There is one angular apical papilla flanked on each side by up to 8 block-like contiguous oral papillae. The second oral tentacle pore is small, opening away from the mouth armed with 3–4 block-like tentacle scales on the inner edge, 3–5 on the outer. The outer scales arise on a triangular plate situated proximal to the first ventral arm plate. The adoral shields are relatively short and narrow, about 3 times as long as broad. The oral shield is pentagonal with a slightly obtuse proximal angle and a straight distal edge, often butting on to another pentagonal plate—almost the mirror image of the oral shield, occasionally there is a small supplementary plate at an inner corner or outer edge. The genital slits are not easily distinguished being obscured by skin but extend the full length of the ventral interradial area. Specimens infected with an athenate hydroid—*Hydractinia* sp.—often have fragmented, ill-defined plates.

The arms are 5 times the disk diameter, and are smooth in profile viewed from the dorsal surface. The dorsal arm plates are not particularly swollen in profile, fan shaped and contiguous at least on proximal segments, slightly longer than broad. These plates are often fragmented by an irregular suture which runs down the mid line. The first three segments of the arm within the disk appear to be slightly swollen. The first ventral arm plate is pentagonal with a straight proximal edge and an obtuse distal angle. Subsequent plates are broadly pentagonal with a very obtuse proximal angle and a convex distal edge. Only the first 2–4 plates are contiguous. The tentacle pores are small only distinct on the first 3 segments. The tentacle scales are small and spine-like with A.P.1: L2, V2; A.P.2: L2, V0–1; A.P.3: L1, V0, reducing to 1 on the fourth segment which merges with arm spines. The arm spines are short, variable in number but usually 3 or 4 and not equally spaced on the arm.

REMARKS. *H. tessellata* closely resembles *H. abyssorum* Lyman but differs from it by the following characters: 1. The arm comb is made up of irregularly arranged papillae while in *H. abyssorum* there is only one row of square papillae. 2. The oral shield is smaller and appears to be associated



with a second plate of similar shape. 3. The proximal part of the arms is not as swollen as in *H. abyssorum*.

**DISTRIBUTION.** It is found on both sides of the North Atlantic; in the west from off New England north to the Labrador Basin with a bathymetric range of 433–3229 m and in the east from S. Iceland south to off the Azores with a bathymetric range of 1809–4706 m.

*Homophiura abyssorum* (Lyman, 1883)

Fig. 52

*Ophioglypha abyssorum* Lyman, 1883: 238.

*Homalophiura abyssorum* H. L. Clark, 1911: 326; 1939: 112–113.

*Ophiurolepis abyssorum* Hertz, 1927a: 93.

**MATERIAL STUDIED.** MCZ: Blake Stn 140, off Virgin Gorda, West Indies, 1974 m, HOLOTYPE.

BMNH: J. Murray Expedition, Stn 135, Maldive Area, 2727 m, 1 specimen.

The disk is pentagonal, slightly elevated covered with large plates amongst which the centrodorsal and the primary radial plates are distinct; plates may be separated by thickened skin; diameter up to 10 mm. The radial shields are large, slightly less than half the disk radius in length and are longer than broad, and separated by a row of plates. The arm comb consists of a few square papillae at the base of the radial shields.

There is one small, pointed, often angular apical papilla flanked on each side by up to 6 block-like usually contiguous papillae of which the distalmost ones are the largest. The second oral tentacle pore emerges superficially outside the mouth slit and is armed with 3–5 rounded oral papillae. The adoral shields are relatively short but longer than broad. The oral shield is large extending up to half the interradial area in length; pentagonal in shape with an acute proximal angle and a straight distal edge; the shield is contiguous distally with a large plate, usually of equal width. The genital slits are long reaching to the edge of the disk and are edged with rounded or block-like papillae. The disk plates adjacent to the slits are large the same length as the slits.

The arms are about 3–4 times the disk diameter and rounded. The dorsal arm plates are tear-drop shaped although in some specimens they may be fragmented, with only the first 2–3 contiguous. The first ventral arm plate is hexagonal nearly pentagonal, truncated proximally; the second is also hexagonal then subsequent plates become more triangular, all are separated. Tentacle pores are small, conspicuous only on the first three arm segments each is armed with small rounded or slightly pointed tentacle scales as follows: A.P. 1: L2–3, V1; A.P. 2–3: L2, V0. The arm spines are small, pointed and peg-like, usually numbering 3 with one situated dorsally, the other two more ventral, occasionally there may be 4–5 spines.

**REMARKS.** *H. abyssorum* is compared with *H. tessellata* under that species. Lyman described the genital papillae as present only on the distal portion of the genital slits whereas examination of the holotype shows them to be present along the whole length of the slits on some interradial.

Dr F. J. Madsen (personal communication) considers it was perhaps unnecessary to describe *Homalophiura abyssorum africanum* Madsen, 1947, as a separate subspecies, and that it should be treated as another record of *H. abyssorum*.

**DISTRIBUTION.** *H. abyssorum* has been recorded from the Western tropical Atlantic off Virgin Gorda, West Indies, at a depth of 1974 m and in the east off the Straits of Gibraltar (35°43'N; 8°16'W) at a depth of 2150–2300 m. It has also been recorded from the Indian Ocean at 2727 m.

*Ophiurolepis inornata* (Lyman, 1878)

Fig. 53

*Ophioglypha inornata* Lyman, 1878: 97; 1882: 73–74; Koehler, 1904: 40; 1907: 262–263.

*Homalophiura inornata* H. L. Clark, 1915: 326; Mortensen, 1927: 327–328; Mortensen, 1936: 327–329; Koehler, 1922: 387.

*Ophiurolepis inornata* Madsen, 1969: 132.

**MATERIAL STUDIED.** BMNH: HMS *Challenger* Stn 106, 1°47'N: 24°26'W, 3330 m, HOLOTYPE, 2 PARATYPES; *Discovery* Stn WS212, 49°22'S: 60°10'W, 242–249 m, 2 specimens; WS820, 52°53'N: 61°51'W, 351–367 m, 3 specimens; WS236, 46°55'S: 60°40'W, 272–300 m, 4 specimens.



The disk is pentagonal covered with small plates amongst which the centrodorsal and primary radial plates are conspicuous, being usually larger than the others. The radial shields are triangular to teardrop shaped, separated and longer than broad, slightly greater than a quarter the disk radius in length. The arm combs consist of rounded, slightly elongated papillae which become smaller towards the ventral side.

There is one pointed angular apical papilla flanked on each side by 5–7 contiguous block-like oral papillae, the second distalmost of which is the largest and lies between the second oral tentacle pore and the mouth slit. Often there is an accessory plate lying distal to the apical papillae. The second oral tentacle pore is relatively large, arising superficially outside the mouth slit, and armed with 3–5 tentacle scales on each side. The adoral shields are relatively short but longer than broad. The oral shield is rounded pentagonal, longer than broad, not extending beyond half the interradial area in length; in some specimens the shield may be divided longitudinally. The genital slits are short, lying adjacent to first lateral arm plates. A series of irregularly arranged, low granules continues from the distal portion of the genital slits to the edge of the disk.

The arms are about 3–4 times the disk diameter, not particularly noded in outline. The dorsal arm plates are nearly rhombic proximally becoming fan shaped, and contiguous along most of the arm; individual plates are often divided by a longitudinal furrow. The first two ventral arm plates are hexagonal, longer than broad, subsequent plates are wider than long approximately hexagonal but becoming triangular; only the first three are contiguous. Tentacle pores are visible on the first 3–4 arm plates, very small and armed with 4 then 2 very small tentacle scales. There are 4 small pointed arm spines, small accessory plates sometimes appear to lie between them.

REMARKS. *O. inornata* bears a resemblance to *Homophiura tessellata* and *H. abyssorum*; it can be distinguished from the former by the short genital slits which do not extend to the edge of the disk like those of *H. tessellata*, and by the smaller oral shield which is separated from the first lateral arm plate by the adoral shields and a supplementary plate unlike *H. tessellata* and *H. abyssorum* where the oral plate is large and appears to abut or nearly abut the lateral arm plates.

DISTRIBUTION. *O. inornata* has a wide distribution being recorded from the Pacific, Indian, Southern and North Atlantic Ocean. In the latter ocean it has been found off St Paul's Rocks, east of Trinidad, off Cap Blanc and the Azores with a bathymetric range of 640–3330 m.

### *Ophiotjalfa vivipara* (Mortensen, 1913)

Fig. 53

*Ophiotjalfa vivipara* Mortensen, 1913a: 40; 1913b: 352; H. L. Clark, 1915: 344; Mortensen, 1933a: 71–72.

MATERIAL STUDIED. BMNH: Ingolf Stn 78, 60°37'N: 27°52'W, 1482 m, SW of Iceland, 1 specimen.

The disk is round to subpentagonal, covered with large tumid plates of which the centrodorsal and primary radial plates are the largest; diameter up to 5 mm. The radial shields are small, less than a quarter of the disk radius in length, broader than long and separated or contiguous only distally. There is an arm comb of a few block-like or slightly pointed spinelets at the base of the arm, although Mortensen (1913a), describing the type, recorded that there were no combs at the base of the arm.

There is one pointed apical papilla flanked on each side by 4–5 block-like contiguous papillae of which the distalmost one is the largest. The second oral tentacle pore opens superficially outside the mouth slit and is armed with 1–3 tentacle scales on each side. The adoral shields are relatively long, about three times as long as broad. The oral shields are rounded with an obtuse proximal angle. The genital slits extend the full length of the ventral interradial area and are not fringed with papillae.

The arms are three times the disk diameter and are slightly noded. The dorsal arm plates are tumid, fan shaped and separated. The first ventral arm plate is bell shaped or trapezoidal subsequent plates are approximately pentagonal with an acute proximal angle and a convex distal edge; on distal segments the ventral arm plates become triangular; all but sometimes the first two are separated. The tentacle pores are only conspicuous on the first four arm segments; the first two pores are armed with 2–3 rounded tentacle scales, the next with 1 or 2—then the rest with just one which becomes smaller distally. There are three short, pointed arm spines.

REMARKS. *O. vivipara* can be distinguished by its tumid disk and dorsal arm plates, and the lack of genital papillae.

DISTRIBUTION. This species has been recorded from the Davis Strait (no depth record) and off SW Iceland at 1438 m.

*Anthophiura ingolfi* Fasmer, 1930

Fig. 53

*Anthophiura ingolfi* Fasmer, 1930: 4; Schoener, 1969: 128–131.*Aspidophiura minuta?* Koehler, 1896a: 72 [non *Aspidophiura minuta*, Lyman?]MATERIAL STUDIED. ZMC: *Ingolf* Stn 11, 64°34'N: 31°12'W, 2430 m, HOLOTYPE.

COB: BIOGAS Stn 6, DS51, 2430 m, 2 specimens.

The disk is rounded, domed and covered with large plates, the centrodorsal plate is star shaped and partly overlies the primary radial plates; diameter up to 5 mm. The radial shields are large, nearly as broad as long, contiguous for most of their length. There are no arm combs.

There is one triangular apical papilla flanked on each side by 3 block-like contiguous oral papillae of which the dorsalmost one is the largest. The second oral tentacle pore opens superficially outside the mouth slit and is armed with one or two tentacle scales on either side. The adoral shields are about 3 times as long as broad. The oral shield is pentagonal and longer than broad. The genital slits extend from the oral shield nearly to the edge of the disk.

The arms are noded, about three times the disk diameter. There are no dorsal arm plates. The ventral arm plates are bell shaped and present only proximally. The tentacle pores are small armed with small single rudimentary tentacle scale, absent on some pores. There are only 2 pointed arm spines.

REMARKS. This is a very distinctive ophiuroid easily recognised by the star shaped centrodorsal plate, and the limited number of large disk plates, the lack of dorsal arm plate. Fasmer (1930) thought the Koehler's (1896a) record of *Aspidophiura minuta* from the Bay of Biscay was a mistaken identification of *Anthophiura ingolfi*. This view is plausible as the two species appear very similar varying mainly in the presence of an arm comb in *Aspidophiura*.

DISTRIBUTION. *A. ingolfi* has been recorded from both sides of the North Atlantic; in the west from off the eastern United States to the west of Iceland in the Labrador Basin and in the east from the Bay of Biscay, with a bathymetric range of 2430–2862 m.

*Ophiomisidium speciosum* Koehler, 1914

Fig. 54

*Ophiomisidium speciosum* Koehler, 1914: 34–36; Schoener, 1969: 131–133; Litvinova, 1981: 122.*Ophiophycis gracilis* Mortensen, 1933d: 455–461; Litvinova, 1981: 122.MATERIAL STUDIED. USNM: *Albatross* Stn 2415, 30°44'N: 79°26'W, 792 m, 2 SYNTYPES.

The disk is pentagonal, dominated by the pentagonal centrodorsal plate and the primary radial plates, diameter up to 5 mm. The radial shields are large about half the disk radius in length, longer than wide and separated by a large dorsal arm plate distally. Interradially each pair of radial shields is separated by a single row of two plates; the proximal one is the largest, pentagonal and longer than wide. The distal one is rectangular, wider than long.

There is one pointed apical papillae flanked on each side by one long rectangular oral papilla. The second oral tentacle pore opens outside the mouth slit and is armed with one, round, relatively large tentacle. The adoral shields are rectangular. The oral shield is rounded pentagonal. The genital slits are short equal in length to the first lateral arm plate and not edged with papillae.

The arms are short, equal in length to the disk diameter. The first four proximal lateral arm plates are distinctly enlarged. The first two dorsal arm plates are rounded distally contiguous; subsequent plates are fan shaped and separated. The first ventral arm plate is pentagonal and longer than wide, subsequent ones are axe-shaped, all are separated. The tentacle pores are relatively large armed with one rounded tentacle scale. There are 3 pointed arm spines proximally, 2 distally.

REMARKS. *O. speciosum* can be distinguished from *O. pulchellum* chiefly because it lacks the rugose, spine-like boss on the primary disk plates and dorsal arm plates.

Litvinova (1981) has commented on the similarity of this genus to *Ophiophycis*. Differences between them centre on: 1. the lateral arm plates are widened and more elongated giving the ventral side of the disk a flatter appearance in *Ophiophycis* than in *Ophiomisidium*. 2. The arm spines are pointed in *Ophiomisidium* but flattened with squared off tips in *Ophiophycis*. Further



investigation may prove that such differences are specific not generic. Should this be so then *Ophiophycis* has priority as the generic name.

**DISTRIBUTION.** This species has been recorded from off Brazil and Florida with a depth range of 547–1472 m.

*Ophiomysidium pulchellum* Wyville Thomson, 1877

Fig. 53

*Ophiomysidium pulchellum* Wyville Thomson, 1877: 67; Lyman, 1878: 118; 1882: 96; Koehler, 1907: 266.

*Ophiomysidium pulchellum* Koehler, 1914: 32–37; A. M. Clark & Courtman-Stock, 1976: 190–191.

**MATERIAL STUDIED.** BMNH: HMS *Challenger* Stn 142, S of Cape Town, 35°4'S: 18°37'E, 274 m, 3 specimens.

The disk is subpentagonal, covered with a few large plates amongst which the centrodorsal and primaries are distinct; diameter up to 5 mm. Most of the disk plates, except the radial shields, and the proximal dorsal arm plates carry a rugose, central, spine-like boss. The radial shields are large, more than half the disk radius in length, longer than broad, meeting about half way down their length then diverging proximally or sometimes contiguous proximally separated distally.

There is one triangular apical papilla flanked by one or two oral papillae; the first is slightly pointed, the second long thin and block-like running the length of the mouth slit. The second oral tentacle pore arises outside the mouth slit and is armed with one rounded scale. The adoral shields are relatively large, longer than broad. The oral shield is small pentagonal with an acute proximal angle and a convex distal edge. The genital slits are short often difficult to discern.

The arms are noded, only about twice the disk diameter. The proximal lateral arm plates are distinctly enlarged. The dorsal arm plates are triangular, proximal ones with a central rugose boss, and separated. The first ventral arm plate is hexagonal subsequent ones pentagonal, the first three may be contiguous. Tentacle pores are present only on the first 4 segments, each pore is armed with one round scale. There are 3–4 irregularly shaped, slightly rugose arm spines, the middle spines usually the longest, proximally nearly one segment long reducing in size rapidly along the arm.

**REMARKS.** *O. pulchellum* can be distinguished from *O. speciosum* primarily by the presence of rugose bosses on the disk and dorsal arm plates.

**DISTRIBUTION.** This species has been recorded in the eastern Atlantic from the Bay of Biscay south to off the Cape of Good Hope with a bathymetric range of 70–3063 m and in the western Atlantic off South Carolina 440 m and off Pernambuco, Brazil 270 m.

*Ophiophycis mirabilis* Koehler, 1901b

Fig. 54

*Ophiophycis mirabilis* Koehler, 1901b: 222; 1909: 163; Cherbonnier, 1970: 348; Cherbonnier & Sibuet, 1972: 1387.

**MATERIAL STUDIED.** IOS: *Discovery* Investigations Stn 9042, 45°15'N: 11°12'W, 1662–1541 m, 1 specimen.

COB: BIOGAS Stn 6, 23, 1980 m, 1 specimen.

The disk is pentagonal, fringed by stout squared tipped spines, which are in fact modified arm spines, diameter up to 6 mm. The disk is dominated by the large pentagonal centrodorsal and primary radial plates. The radial shields are longer than broad, greater than  $\frac{1}{2}$  the disk radius in length, and contiguous along the mid-portion of the plate. Interradially pairs of radial shields are separated by a single row of two plates.

There are one or two pointed apical papillae flanked on each side by 2–3 contiguous block-like papillae. The second oral tentacle pore opens superficially away from the mouth slit, and is armed with one small, slightly pointed tentacle scale. The adoral shields are large, longer than broad. The oral shield is pentagonal and not quite half the disk radius in length. The genital slits are small partially hidden beneath the elongated first lateral arm plates.

The arms are only one or two times the disk diameter in length. The first two dorsal arm plates are triangular or trapezoidal and contiguous, the subsequent plates rounded triangular and separated. The first ventral arm plate is approximately rectangular or pentagonal subsequent plates are pentagonal with a straight proximal edge and an obtuse distal angle; all the ventral arm plates are separated. The tentacle pores on the proximal arm are large and each is armed with a small pointed tentacle scale. The lateral arm



plates of the first 5 arm segments are widened and elongated. There are two or three flattened rugose arm spines.

REMARKS. *Ophiophycis mirabilis* resembles *Ophiomisidium pulchellum* and *O. speciosum*; all three have enlarged lateral arm plates, reduced disk plating and simple oral armament. *Ophiophycis mirabilis* can be distinguished by the flatter arm spines, the lack of knobs on the dorsal disk and arm plates and a different arrangement of the plates of the ventral interradial area.

DISTRIBUTION. This species has been recorded only in the eastern Atlantic from the Bay of Biscay south to the Azores with a bathymetric range of 1175–1662 m.

*Ophiambix meteoris* Bartsch, 1983a

Figs 54 & 57e, f

*Ophiambix meteoris* Bartsch, 1983a: 97–100; 1983b: 13–14.

MATERIAL STUDIED. ZSM: Meteor Stn M3, 30/AT3 42°55.4'N: 14°07.9'W, 5260 m, 4 PARATYPES.

The disk is round, covered with thin imbricating plates; neither centrodorsal nor primary plates distinct, plates are often obscured by a covering of pointed spinelets, which have an elaborate structure (see Fig. 57); diameter up to 5 mm. Radial shields are absent. The proximal portion of the ventral interradial area is naked without plates.

There are up to three pointed apical papillae flanked on either side by 2 to 4 pointed irregularly arranged oral papillae. The second oral tentacle pore is large and opens outside the mouthslit and is armed with up to 6 pointed tentacle scales. The adoral shields are long, thin and slightly bowed, separating the oral shield from the first lateral arm plate. The oral shield is small and rounded.

The arms are flattened about 1–3 times the diameter of the disk. Proximally, it is often difficult to distinguish the dorsal arm plates as the disk plates appear to continue to the arm so there is no distinct boundary between the disk and the arm. Distally dorsal arm plates can be recognised; they are, usually, irregularly rectangular contiguous and flanked on each side by a triangular accessory plate. At the ends of the arm the dorsal arm plates are rhombic and the accessory plates are absent. The ventral arm plates are approximately rectangular and contiguous proximally. The tentacle pores are large, open and armed with up to 8 pointed tentacle scales on proximal segments. There are 4–5 arm spines proximally reducing to three distally; the spines are rugose, flattened with an irregular open lattice work structure, slightly flared free end (see Fig. 57). Distally the ventral arm spines may be slightly hooked.

REMARKS. This species differs from the other *Ophiambix* species by the shape of the dorsal disk spinelets, the shape of the arm spines. *Ophiambix* has been transferred from the Ophiacanthidae because the second oral tentacle pore arises outside the mouth slit and the dental and oral plate characters are more consistent with this family (Paterson & Baker, in preparation).

DISTRIBUTION. *Ophiambix meteorensis* has been found off Spain in the Iberian Basin at 5315 m.

*Ophiambix devaneyi* sp. nov.

Figs 54 & 57a–d

MATERIAL STUDIED. Pillsbury Stn 931, 15°32'N: 61°13'W, 146–494 m, HOLOTYPE.

The disk is round, covered with thin imbricating plates amongst which neither the primary plates nor the radial shields are distinct; diameter 3 mm. The plates carry small but very elaborate pyramidal spinelets (see Fig. 57b). The ventral interradial area is covered with thin plates without spinelets.

There are one to two spine-like apical papillae flanked on each side by two, spaced, spine-like oral papillae. The second oral tentacle pore is large and opens outside the mouth slit; it is armed with 4 pointed, spine-like tentacle scales, two on the first ventral arm plate and two on the adoral shield. The adoral shields are narrow, longer than broad. The oral shield is irregular in shape, sometimes rounded triangular in shape. The genital slits are adjacent to the first lateral arm plate.

The arms appear to be short about equal to the disk diameter in length. They are not clearly demarked from the disk and spinelets extend on to the arm. Dorsal arm plates are only really distinct distally and appear to be fan shaped and just contiguous; proximally they appear to be flanked by approximately triangular accessory plates but spinelets obscure the plate boundaries. The ventral arm plates are rectangular longer than broad, slightly indented laterally adjacent to the tentacle pores, and contiguous along most of the arm. The lateral arm plates are enlarged and flared at their distal ends, the second lateral



**Fig. 57** Ophiuridae: Ophiurinae. a–f *Ophiambix devaneyi* holotype d.d. 3 mm: (a) Part of dorsal side; (b) detail of dorsal side of disk showing disk spinelets, (c) ventral side, (d) of jaw; e–f *Ophiambix meteoris* paratype, d.d. 3–5 mm; (e) close up of jaw; (f) showing arm spines and disk spinelets. All SEM pictures taken of an ISI 60A with environmental chamber.



arm plate is particularly enlarged and nearly reaches the edge of the disk. The tentacle pores are large and open, each is armed with two spine-like tentacle scales—one on the ventral arm plate and one on the lateral arm plate. There are 3–4 arm spines proximally; the ventralmost one is hooked then the others become progressively fan shaped towards the dorsal side; the dorsalmost or second dorsalmost spines are the largest.

**TYPE LOCALITY.** *Pillsbury* Stn 931, 15°32'N: 61°13'W, 146–494 m off Dominica Leeward Is. The holotype is deposited in the National Museum of Natural History, Smithsonian Institution, Washington D.C.

**DERIVATION OF NAME.** *O. devaneyi* is named after the late Dennis Devaney, of the Bernice P. Bishop Museum, Honolulu, Hawaii.

**REMARKS.** *O. devaneyi* can be distinguished from *O. meteoris* by 1. shape of the disk spinelets, 2. the enlarged, flared lateral arm plates, 3. the shape of the arm spines, 4. the number of tentacle scales.

Although the specimen is small it has sufficient developed characters to distinguish it from the other *Ophiambix* species.

### *Uriopha ios* Paterson, 1980

Fig. 55

*Uriopha ios* Paterson, 1980: 211–213.

**MATERIAL STUDIED.** **IOS:** *Discovery* Investigations Stn 8524/1, 20°46'N: 22°42'W, 4412 m, HOLOTYPE and 10 PARATYPES.

The disk is round to subpentagonal, high, sometimes domed, covered by a dense coating of granules which obscure the underlying plates, the granules extend on to the ventral interradiial areas and over the oral and adoral shields; diameter up to 4 mm. Arm combs are absent.

There is one pointed apical papilla flanked on each side by 3–4 oral papillae broadening progressively from peg-like to block-like. The second oral tentacle pore arises superficially away from the mouth slit and is armed with 2–3 tentacle pores each side. The adoral shields are about four times as long as broad. The oral shield is triangular situated totally proximal to the genital slits.

The arms are nearly cylindrical and fragile. The dorsal arm plates are triangular to fan shaped and separated. The ventral arm plates are pentagonal, indented laterally by the tentacle pores with a convex distal edge. The tentacle pores are relatively small armed with 3 tentacle scales on the first arm pore then one sometimes two on subsequent pores. There are two conical, pointed arm spines about half an arm segment in length.

**REMARKS.** This species can be readily distinguished by the granulated disk, position and armament of the second oral tentacle pore, the number and shape of arm spines and the shape of the arms.

**DISTRIBUTION.** *U. ios* has only been recorded from the type locality west of Cap Blanc at a depth of 4412 m.

### *Ophiotypa simplex* Koehler, 1897

Fig. 55

*Ophiotypa simplex* Koehler, 1897: 3–6; 1907: 255; 1909: 145. Litvinova, 1975: 196–198.

**MATERIAL STUDIED.** **IOS:** *Discovery* Investigations Stn 8524/1, 20°46'N: 22°42'W, 4412 m, 9 specimens.

The disk is round, domed and dominated by the primary plates, only one other plate lying interradiially. No radial shields or arm combs are present; diameter up to 5 mm.

There is one large triangular apical papilla, individual oral papillae are not developed instead there is a long narrow bar along the edge of the jaw. The second oral tentacle scale opens outside the mouth adjacent to the first ventral arm plate and is armed with a large round tentacle scale. The adoral shields are large swollen, just wider than long. The oral shield is small, barely distinguishable, triangular with a convex distal edge.



The arms are short noded and flattened dorsoventrally. The dorsal arm plates are small, triangular, separated, and appear to lie beneath the level of the very tumid lateral arm plates. The ventral arm plates are pentagonal, often with a convex distal edge, and separated; they too appear to lie beneath the level of the lateral arm plates. The tentacle pores are relatively large and armed with one large rounded tentacle scale. There is one short, pointed conical spine.

REMARKS. *O. simplex* is easily recognised by its overall 'star shape', the domed disk dominated by the primary plates and by the swollen lateral arm plates which carry only one arm spine.

DISTRIBUTION. This species has been recorded in the NE Atlantic from off the Azores and Cape Verde Is, it has also been found in the Venezuelan Basin in the Caribbean and from the Indian Ocean. It appears to be a member of the lower abyssal fauna being recorded at depths of 3595–4366 m.

*Perlophiura profundissima* Belyaev & Litvinova, 1972

Fig. 55

*Perlophiura profundissima* Belyaev & Litvinova, 1972: 7–11; Litvinova 1975: 198–199.

MATERIAL STUDIED. COB: BIOGAS Stn 5: DS82, 4462 m, 1 specimen.

INCAL: Stn ØS5, 47°32'2N: 9°34'7W, 4248 m, 1 specimen; Stn WS08, 47°29'N: 9°34'1W, 4287–4301 m, 2 specimens; Stn WS09, 47°27'9N: 9°34'W, 4277 m, 1 specimen; Stn WS10, 47°27'3N: 9°39'W, 4354 m, 1 specimen.

IOS: *Discovery* Investigations Stn 8524/1, 20°46'N: 22°42'W, 4412 m, 30 specimens.

The disk is round to pentagonal, covered with only the primary plates, occasionally one of the radial plates may be divided, each plate is thin and fenestrated, diameter up to 4.8 mm. This species resembles the post metamorphosed stage of many other ophiuroids.

There is one pointed, nearly triangular, apical papillae. The oral papillae are often not developed, instead there is a long continuous, narrow plate along the edge of the jaw. However, Belyaev & Litvinova (1972) found some specimens with up to 3 rounded discrete oral papillae on each side. The second oral tentacle pore opens outside the mouth slit, adjacent to the first ventral arm plate. The adoral shields are of varying length. The oral shield is irregular in shape varying from triangular to pentagonal. In the specimens from the *Discovery* there are two rectangular plates flanking the oral shield; these plates appear to be missing in the specimen figured by Belyaev & Litvinova (1972), suggesting that the plating in this species is relatively variable.

The arms are noded, long and fragile. The dorsal arm plates are small transversely dumb-bell shaped and broader than long. The first and second ventral arm plates are hexagonal, longer than broad, subsequent plates are pentagonal becoming triangular. The lateral arm plates are long. The tentacle pores are small, each armed with one small, rounded tentacle scale. There are two or three very short pointed arm spines.

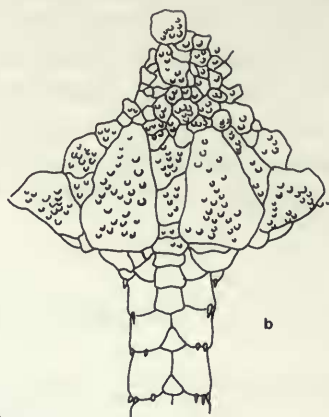
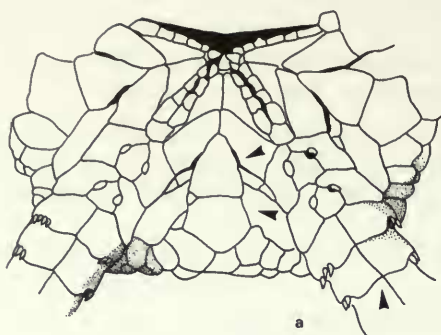
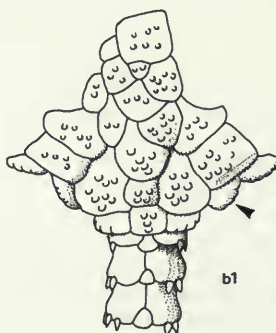
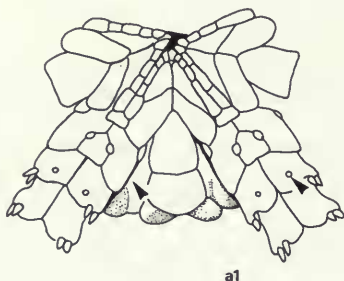
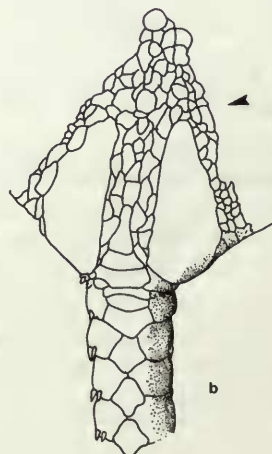
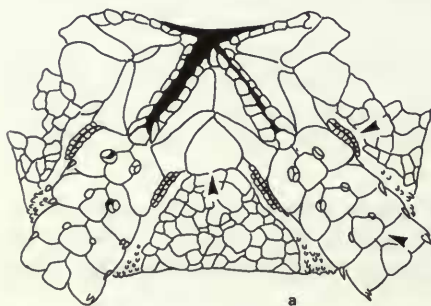
REMARKS. This is a distinctive species characterised by several neotonous features: a disk comprising large primary plates which are thin and fenestrated; rudimentary apical and oral papillae with ill-defined adoral and oral shields; long lateral arm plates and rudimentary dorsal arm plates; small arm spines. The relatively small size of this species perhaps accounts for its comparatively recent discovery.

DISTRIBUTION. *P. profundissima* is a member of the lower abyssal zone (sensu Menzies, George & Rowe, 1973) rarely having been recorded shallower than 4000 m. Besides the NE Atlantic it has been recorded from the Pacific and Indian Oceans and the Caribbean Sea with a bathymetric range of 2265–8135 m.

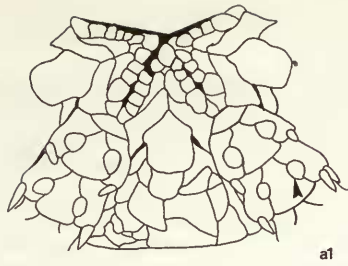
### OPHIOLEPIDINAE

DIAGNOSIS. This subfamily of the Ophiuridae is characterised by the disk covered with distinct plates amongst which the centrodorsal and primary plates are distinct; radial shields conspicuous; usually one apical papilla flanked by a series of continuous oral papillae; the second oral tentacle pore opens within the mouth; arms with distinct dorsal and ventral arm plates; arm spines short and appressed.

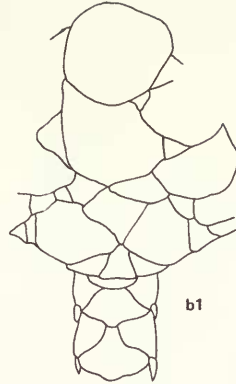
## OPHIURIDAE : OPHIOLEPIDINAE

**Ophiomusium lymani**a,ba1,b1**Ophiomusium africanum \*****Ophiosphalma armigerum**

**Fig. 58** Key to the Ophiuridae: Ophiolepidinae. *Ophiomusium* and *Ophiosphalma*: (a) ventral; (b) dorsal view of disk. Bar scales = 1 mm. \*—not described in text.



a1

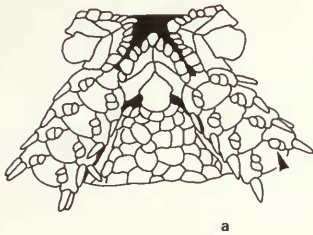


b1

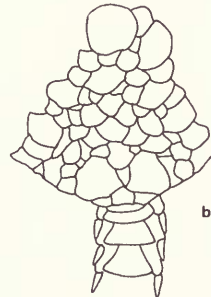
**Ophiozonella sincera**

a, b

a1, b1



a



b

**Ophiozonella molesta**

Fig. 59 Ophiuridae: Ophiolepidinae. *Ophiozonella*. Captions as in Fig. 56.

***Ophiomusium lymani* Wyville Thomson, 1873**

Fig. 58

*Ophiomusium lymani* Wyville Thomson, 1873: 174; Lyman, 1878: 113; 1882: 90; 1883: 245; Koehler, 1895: 453; 1896a: 72; 1896b: 204; 1898: 42; Lütken & Mortensen, 1899: 137; Nichols, 1903: 254; Koehler, 1904: 58; Kemp, 1905: 194; Schmidt, 1904: 24; Koehler, 1907: 264; 1909: 161; Grieg, 1910: 33; H. L. Clark, 1911: 107; Mortensen, 1913b: 354; Farran, 1913: 34; Koehler, 1914: 26; Koehler, 1922: 411; 1924: 330; Mortensen, 1927: 253; 1933a: 100–102; H. L. Clark, 1939: 67; Barham *et al.*, 1967: 777; Schoener, 1967: 650–652; 1968: 84–85; Okutami, 1969: 21–22; Rowe, 1971: 569–581; Ayala & Valentine, 1971: 51–57; Doyle, 1971: 661–664; Cherbonnier & Sibuet, 1972: 1386–7; A. M. Clark & Courtman-Stock, 1976: 191; Murphy, Rowe, Haedrich, 1976: 339–348; Gage & Tyler, 1982: 73–83; Gage *et al.*, 1983: 299–300; Bartsch, 1983: 18–19.

*Ophiomusa lymani* Hertz, 1927: 103–105; H. L. Clark, 1939: 128.

MATERIAL STUDIED. **BMNH:** *Porcupine*. SYNTYPES. HMS *Challenger* Stn 76, 38°11'N: 27°9'W, 1646 m, 1 specimen; HMS *Challenger* off Tristan d'Acunha, 1829 m, 2 specimens; Stn 169, 37°34'S: 179°22'E, 1280 m, 1 specimen. Irish Fisheries Stn SR944, 51°22'N: 12°41'W, 1767 m, 7 specimens.

**COB:** BIOGAS Stn 1: DS10, 2240 m, 4 specimens; DS11, 2205 m, 12 specimens; DS12, 2180 m, 6 specimens; DS13, 2165 m, 6 specimens; DS15, 2246 m, 33 specimens; DS16, 2325 m, 2 specimens; DS17, 2103 m, 7 specimens; DS18, 2138 m, 2 specimens; DS35, 2226 m, 1 specimen; DS36, 2147 m, 2 specimens; DS61, 2250 m, 2 specimens; DS62, 2175 m, 4 specimens; DS63, 2126 m, 7 specimens; CV08, 2180 m, 20 specimens; CV09, 2119 m, 16 specimens; CV10, 2108 m, 19 specimens; CV20, 2282 m, 2 specimens; CV23, 2034 m, 5 specimens; CV24, 2025 m, 47 specimens; CV25, 1985 m, 13 specimens; CP01, 2245 m, 32 specimens; CP02, 2177 m, 40 specimens; CP03, 2119 m, 6 specimens; CV39, 2350 m, 4 specimens; CP08, 2177 m, 25 specimens; CP26, 2115 m, 97 specimens; CP27, 1920 m, 38 specimens.



BIOGAS Stn 2: DS60, 3742 m, 2 specimens; CV12, 2775 m, 2 specimens; CV37, 3000 m, 1 specimen; CV40, 2860 m, 1 specimen; CP09, 2171 m, 94 specimens; CP12, 2925 m, 7 specimens; CP28, 3380 m, 8 specimens.

Stn 6: DS25, 2096 m, 12 specimens; DS26, 2076 m, 122 specimens; DS49, 1845 m, 3 specimens; DS50, 2124 m, 5 specimens; DS51, 2430 m, 162 specimens; DS52, 2006 m, 14 specimens; DS70, 2150 m, 3 specimens; DS86, 1950 m, 6 specimens; DS87, 1913 m, 19 specimens; CV32, 1895 m, 42 specimens; CP07, 2170 m, 1089 specimens; CP23, 1980 m, 7 specimens; CP24, 1995 m, 39 specimens; CP25, 1894 m, 4 specimens.

INCAL: DS01, 57°59'7N: 10°39'8W, 2091 m, 140 specimens; DS02, 57°58'8N: 10°48'5W, 2081 m; DS05, 56°28'1N: 11°11'7W, 2503 m, 8 specimens; DS06, 56°26'6N: 11°10'5W, 2494 m, 4 specimens; CP01, 57°57'0N: 10°55'0W, 2068 m, 95 specimens; CP03, 56°38'N: 11°06'4W, 2466 m, 82 specimens; CP04, 56°33'2N: 11°11'3W, 2483 m, 5 specimens; CP08, 50°14'7N: 13°13'5W, 2644 m, 16 specimens; CP09, 50°15'4N: 13°15'8W, 2659 m, 13 specimens; CP10, 48°25'5N: 15°10'7W, 4823 m, 1 specimen. WS01, 50°19'4N: 13°08'1W, 2550 m, 81 specimens; WS02, 50°19'3N: 12°55'8W, 2498 m, 97 specimens; WS09, 47°28'8N: 9°34'W, 4277 m, 4 specimens. ØS01, 50°14'9N: 13°10'9W, 2634 m, 2 specimens; ØS02, 48°19'2N: 15°15'9W, 4829 m, 1 specimen; ØS04, 46°03'9N: 10°12'8W, 4796 m, 2 specimens.

IOS: *Discovery* Investigations: Stn 7423, 37°51'N: 27°06'W, 2283 m, 4 juveniles; Stn 8511/1, 41°55'N: 11°15'W, 2389–2399 m, 3 specimens; Stn 8512/4, 42°15'N: 11°36'W, 2281–2245 m, 1 specimen; Stn 8521/6, 20°48'N: 18°53'W, 3064–3070 m, 2 specimens; Stn 9133/5, 20°57.5'N: 18°13.7'W, 2112–2160 m, 3 specimens; Stn 9753/4, 50°54.9'N: 12°12'W, 1942–1947 m, 20 specimens; Stn 9753/7, 50°54.5'N: 12°10.9'W, 1942 m, 5 specimens; Stn 9753/8, 50°54.6'N: 12°11.1'W, 1942 m, 9 specimens; Stn 9756/3 49°48'N: 14°14.8'W, 4080–4156 m, 2 specimens.

SMB: *RRS Challenger II*: Stn ES4, 56°52'N: 10°01'W, 1993 m, 35 specimens; Stn ES12, 56°49'N: 10°15'W, 2076 m, 6 specimens; Stn ES10, 56°37'N: 10°04'W, 2540 m, 7 specimens; Stn ES14, 56°45'N: 9°46'W, 1770 m, 2 specimens; Stn ES18, 56°44'N: 09°20'W, 1392 m, 1 specimen.

The disk is pentagonal, high covered with relatively small plates amongst which usually only the centro-dorsal plate, but sometimes the primary radial plates can be distinguished, diameter up to 30 mm. The radial shields are large, about  $\frac{1}{2}$  the disk radius in length, longer than broad and slightly triangular in shape, usually separated by a single row of plates. All the dorsal disk plates are textured, with round glassy beads embedded in the matrix of the plate. There is a rudimentary arm comb of small, rounded, irregularly arranged papillae.

There is one rounded or slightly pointed apical papilla flanked on each side by 5–6 contiguous, block-like oral papillae, the distal most one of which is the largest. The adoral shields are large, slightly longer than broad. The oral shield is pentagonal to nearly triangular with a straight distal edge. Distally the oral shield usually abuts on a plate of similar shape but almost a mirror image. The genital slits are short and lie adjacent to the oral shield and the first lateral arm plate.

The arms are cylindrical, about 4–5 times the disk diameter. The dorsal arm plates are small, the first three are rectangular and contiguous, subsequent plates triangular and well separated. Ventral arm plates are present only on the first two arm segments, and are pentagonal to irregularly hexagonal in shape. Tentacle pores are present on the first two arm segments, each is armed with one oblong tentacle scale. There are 7–12 short pointed arm spines.

REMARKS. This is a very common and easily identified member of the abyssal fauna. Schoener (1967) has described the juvenile stages, showing that at disk diameters of 2 mm they have three pairs of tentacle pores but as growth proceeds the proximal segment becomes incorporated into the mouth leaving two pairs of arm pores, Gage & Tyler (1982) have dealt with its reproductive biology. Murphy, Rowe & Haedrich (1976) investigated the genetic variability of *O. lymani* from different sample sites.

*Ophiomusium africanum* Koehler, 1901 (Fig. 58) differs from *O. lymani* in the heavier texturing of the dorsal disk plates, genital slits which extend from the oral shield to the edge of the disk, and the presence of only two ventral arm plates and the distal pair of tentacle pores emerging on the lateral arm plates not associated with a ventral arm plate. *O. africanum* has only been recorded from the Azores at 219 m.

DISTRIBUTION. This species is found in the Pacific, Indian and Atlantic Oceans. In the North Atlantic it has been recorded from the west from the West Indies north to the Davis Strait and SW Iceland and in the east from SE Iceland south to Cap Blanc, with a bathymetric range of 651–4829 m, more usually in the shallower end of this range.

*Ophiosphalma armigerum* (Lyman, 1878)

Fig. 58

*Ophiomusium armigerum* Lyman, 1878: 109; 1882: 86–87; Koehler, 1914: 31–32.*Ophiomusium planum* Lyman, 1878: 218; 1882: 99; Koehler, 1896c: 242; 1899: 26; 1906: 6; 1907: 265; 1914: 26; Grieg, 1910: 36; Nobre, 1931: 94.*Ophiosphalma armigerum* H. L. Clark, 1941: 97; Madsen, 1951: 109; Schoener, 1968: 136–139; Bartsch, 1983b: 19.*Ophiosphalma planum* H. L. Clark, 1941: 98; Madsen, 1951: 108.MATERIAL STUDIED. **BMNH:** HMS *Challenger* Stn 332, 37°29'S: 27°31'W, 4023 m, HOLOTYPE; HMS *Challenger* Stn 83, 33°13'N: 18°13'W, 3018 m, 1 specimen; HMS *Challenger* Stn 106, 1°47'N: 24°26'W, 3383 m, 2 specimens; Norman collection N. Atlantic, 5 specimens.**COB:** BIOGAS Stn 2: CP12, 2925 m, 19 specimens; Stn 4: CV35, 4721 m, 1 specimen; CP05, 3850 m, 4 specimens; CP15, 4715 m, 4 specimens; CP16, 4825 m, 5 specimens; CP17, 4706 m, 1 specimen; Stn 5: CV34, 4406 m, 1 specimen; CP06, 4460 m, 3 specimens; CP19, 4434 m, 1 specimen; CP20, 4459 m, 10 specimens; CP22, 4475 m, 1 specimen.**INCAL:** DS13 46°01'9N: 10°17'9W, 4822 m, 1 specimen; CP12, 46°00'5N: 10°18'3W, 4796 m, 1 specimen; CP13, 46°02'1N: 10°14'8W, 4800 m, 4 specimens; WS03, 48°19'2N: 15°23'3W, 4823 m, 8 specimens; WS07, 47°30'6N: 9°37'6W, 4296 m, 1 specimen; WS08, 47°30'5N: 9°32'9W, 4826 m, 6 specimens; WS09, 47°28'8N: 9°34'0W, 4277 m, 2 specimens; WS10, 47°27'3N: 9°30'9W, 4354 m, 3 specimens; ØS04, 46°03'9N: 10°12'8W, 4796 m, 1 specimen.**IOS:** *Discovery* Investigations 27°33'N: 14°41.5'W, 2410 m, 1 specimen.

The disk is pentagonal, occasionally indented interradially, slightly raised and covered with relatively small plates amongst which the primary radial plates are usually distinct but the centrodorsal less so; in some specimens the boundaries of disk plates are obscured by thickened skin; diameter up to 25 mm. The radial shields are large, over half the radius of the disk in length, elongated, longer than broad and separated by many small disk plates. There is an irregularly arranged arm comb of small rounded papillae, in two or three rows. All disk plates are textured with small glassy beads embedded in the plate matrix.

There is one rounded or pointed apical papilla flanked on each side by 6–8 contiguous block-like papillae, the distalmost of which is sometimes curved above the next one. The adoral shields are large longer than broad and flared distally. The oral shield is rounded pentagonal to triangular. The genital slits are short, about 1 arm segment long, lined by about 9–12 block-like papillae.

The arms are cylindrical about 3–5 times the disk diameter. The first three dorsal arm plates are rectangular or pentagonal, subsequent ones are teardrop shaped often with a produced distal edge; only the first four plates are contiguous. The ventral arm plates are pentagonal proximally, triangular on distal segments, all are separated. There are three arm tentacle pores, the first is armed with 2–3 tentacle scales, the rest with 2. There are 5 short conical arm spines.

**REMARKS.** Examination of the material from the Biogas, together with specimens from the BMNH revealed that there are no appreciable differences between *O. armigerum* and *O. planum*. Dr Baker (National Museum of New Zealand), who is preparing a revision of *Ophiomusium* and *Ophiosphalma*, informs me that such differences which have been used to separate them in the past can be correlated with size and stage of development. The name *O. armigerum* has priority.

*O. armigerum* superficially resembles *Ophiomusium lymani* but differs in having ventral arm plates along most of the arm, an additional pair of tentacle pores, genital slits lined by papillae, the different scaling of the disk and shape of the oral shield. This resemblance to *O. lymani* could cause confusion in deep sea photographs. However, *O. lymani* appears to be limited to shallower depths, although recorded from 600 to 4000 m the records below 3000 m for this species need to be investigated. *O. armigerum* is mainly found from 3000–5000 m.

**DISTRIBUTION.** *O. armigerum* has been recorded from both sides of the North Atlantic, in the west from off the West Indies north to Nantucket and in the east from the Bay of Biscay south to Cape Verde Is with a bathymetric range of 1601–5025 m.

*Ophiozonella sincera* (Koehler, 1906)

Fig. 59

*Ophiozona sincera* Koehler, 1906: 11–12; 1907: 251–252.*Ophiozonella sincera* Matsumoto, 1915: 82.



MATERIAL STUDIED. MNHN: *Travailleur & Talisman* 15 Aout 1881, Stn 39, 40°5'N: 9°25'40"W, 1225 m, HOLOTYPE.

The disk is round covered with large plates amongst which the large contiguous primary plates are distinct; diameter 4.5 mm. The radial shields are small less than a quarter of the disk radius in length, rounded, about as broad as long, and separated.

There is one angular or rounded apical papilla flanked on each side by 5 contiguous block-like papillae, the distalmost papilla appears to extend above the adjacent papilla which also is the largest. The adoral shields are relatively large and longer than broad. The oral shield is approximately pentagonal with an obtuse proximal angle, slightly indented lateral sides and a convex distal edge. The genital slits extend to the disk edge but are not lined with papillae.

The arms are short, about twice the diameter of the disk in length. The dorsal arm plates are fan shaped, not contiguous. The ventral arm plates are approximately pentagonal becoming axe shaped distally, contiguous at least proximally. The tentacle pores are large each armed with a rounded tentacle scale. There are two pointed arm spines about three quarters of an arm segment long.

REMARKS. *O. sincera* can be distinguished from *O. molesta* by larger disk plates—although this may be just a difference in size, and the tentacle pores being armed with one tentacle scale while *O. molesta* has two scales per pore.

DISTRIBUTION. *O. sincera* has been recorded from the Bay of Biscay at 1225–1690 m.

### *Ophiozonella molesta* (Koehler, 1904)

Fig. 59

*Ophiozona molesta* Koehler, 1904: 23; 1906: 6; 1907a: 253.

*Ophiozonella molesta* Matsumoto, 1915: 82; 1917: 294; Koehler, 1922a: 425.

MATERIAL STUDIED. MNHN: *Siboga* 1 specimen.

The disk is subpentagonal, low, covered with relatively large plates amongst which the centrodorsal and primary radial plates are distinct; the latter are separated from the centrodorsal by a ring of smaller plates; diameter up to 12 mm. The radial shields are small, less than a quarter of the disk radius in length, about as long as broad, separated or just touching distally.

There is one large rounded apical papilla flanked on each side by 5–6 oral papillae which are pointed proximally becoming block-like distally; the distalmost papilla appears to curve above the adjacent one, this second distalmost oral papilla is also the largest. The adoral shields are longer than broad and flared distally. The oral shield is pentagonal or slightly arrow shaped longer than broad, with an acute proximal angle slight lateral projections and a convex distal edge. The genital slits extend to the edge of the disk.

The arms length is about 2–3 times the disk diameter. The dorsal arm plates are fan shaped, contiguous proximally. The first ventral arm plate is pentagonal, the second trapezoidal with subsequent plates nearly axe shaped; ventral arm plates are contiguous. The tentacle pores are relatively large each is armed with 2 tentacle scales, an inner small one and an outer round large one. There are two pointed arm spines, situated on the ventral portion of the lateral arm plate, they are nearly one arm segment long.

REMARKS. See *O. sincera* for a comparison with this species.

DISTRIBUTION. This species has been recorded once in the North Atlantic off the Cape Verde Islands, 30°1'N: 14°6'W, 2115 m. It has mostly been recorded from the Indo-West Pacific region at depths of 68–1407 m.

## Summary of Taxonomic Proposals and Changes

### 1. New subfamilies and genera

(a) Ophiacanthidae: four new subfamilies proposed.

- (i) Ophiacanthinae, comprising the genera *Ophiacantha* Müller & Troschel 1842, *Ophiacanthella* Verrill, 1899a; *Ophialcaea* Verrill, 1899a; *Ophiogema* Koehler, 1922a; *Ophiolebes* Lyman, 1878 and *Ophiotetra* Verrill, 1899.



- (ii) Ophiotominae, comprising the genera *Ophiotoma* Lyman, 1883; *Amphilimna*, Verrill, 1899a; *Ophiocymbium* Lyman, 1880; *Ophiodaces* Koehler, 1922b; *Ophiodelos* Koehler, 1930; *Ophiolimna* Verrill, 1899a; *Ophiologimus* H. L. Clark, 1911; *Ophiomedeia* Koehler, 1906; *Ophiophiura* H. L. Clark, 1911; *Ophiopristis* Verrill, 1899a; *Ophioprium* Verrill, 1899a; *Ophiosparte* Koehler, 1922b; and *Ophiotrema* Koehler, 1896a.
- (iii) Ophioplinthacinae, comprising the genera *Ophioplinthaca* Verrill, 1899a; *Microphiura* Mortensen, 1911; *Ophiocamax* Lyman, 1878; *Ophiocopa* Lyman, 1883; *Ophiodictys* Koehler, 1922a; *Ophiomelina* Koehler, 1922a; *Ophiomitra* Lyman, 1869; *Ophiomitrella* Verrill, 1899a; *Ophiomytis* Koehler, 1904; '*Ophiophthalmus*' Matsumoto, 1917; *Ophioripa* Koehler, 1922a; *Ophiothamnus* Lyman, 1869; and *Ophiurithamnus* Matsumoto, 1917.
- (iv) Ophiohelinae comprising the genera *Ophiohelus* Lyman, 1878; *Ophiomyces* Lyman, 1869; *Ophiotauma* H. L. Clark, 1938; and *Ophiotholia* Lyman, 1880.
- (b) Ophiuridae: Ophiurinae. New genus erected *Homophiura* with type species *Ophioglypha tessella*, Verrill, 1894.

## 2. Changes at the generic/specific level

### (a) Ophiacanthidae

#### CURRENT USAGE

*Ophiacantha veterna* Koehler, 1906  
*Ophiomitrella levis* Koehler, 1914  
*Ophioprium axiologia* H. L. Clark, 1909  
*Ophiacantha hirsuta* Lyman,  
*Ophioprium rosea* (Lyman, 1878)  
*Ophiacantha (Ophiopristis) permixta*  
 Koehler, 1914

#### PROPOSED CHANGE

*Ophiacantha enopla veterna*  
*Ophiacantha levis*  
*Ophiopristis axiologia*  
*Ophiopristis hirsuta*  
*Ophiacantha rosea*  
*Ophioprium permixtum*

### (b) Ophiuridae

#### (i) Revision of the genus *Homalophiura* H. L. Clark, 1915

#### CURRENT USAGE

*Homalophiura confragosa* (Lyman, 1878)  
*H. inorata* (Lyman, 1878)  
*H. scissa* (Koehler, 1908)  
*H. divisa* (Lütken & Mortensen, 1899)  
*H. flexibilis* (Koehler, 1911)  
*H. inflata* (Koehler, 1897)  
*H. madseni* Belyaev, 1972  
*H. mimaria* (Koehler, 1908)  
*H. nana* (Lütken & Mtsn., 1899)  
*H. scutellata* (Lütken & Mtsn., 1899)  
*H. violinae* Cherbonnier & Sibuet, 1972  
*H. euryplax* H. L. Clark, 1939  
*H. glypta* H. L. Clark, 1939  
*H. intorta* (Lyman, 1878)  
*H. schmidtotti* (Hertz, 1927)  
*H. multispina* Cherbonnier & Sibuet, 1972  
  
*H. abyssorum* (Lyman, 1883)  
*H. clasta* (H. L. Clark, 1911)  
*H. tessellata* (Verrill, 1894)

#### PROPOSED CHANGE

*Ophiurolepis confragosa*  
*Ophiurolepis inornata*  
*Ophiurolepis scissa*  
*Ophiura divisa*  
*Ophiura flexibilis*  
*Ophiura inflata*  
*Ophiura madsen*  
*Ophiura mimaria*  
*Ophiura nana*  
*Ophiura scutella*  
*Ophiura violinae*  
*Ophiura (Ophiuroglypha) euryplax*  
*Ophiura (Ophiuroglypha) glypta*  
*Ophiura (Ophiuroglypha) intorta*  
*Ophiura (Ophiuroglypha) schmidtotti*,  
 Mortensen, 1933a  
*Homophiura abyssorum*  
*Homophiura clasta*  
*Homophiura tessellata*

#### (ii) The *Ophiura irrorata* group

#### CURRENT USAGE

*Ophiura irrorata* (Lyman, 1878)  
*Ophiura concreta* (Koehler, 1901)  
*Ophiura loveni* (Lyman, 1878)

#### PROPOSED CHANGE

*O. irrorata irrorata*  
*O. irrorata concreta*  
*O. irrorata loveni*

- |   |                                   |
|---|-----------------------------------|
| (iii) The <i>Amphiophiura bullata</i> complex |                                   |
| CURRENT USAGE                                 | PROPOSED CHANGE                   |
| <i>Amphiophiura bullata</i>                   | <i>A. bullata bullata</i>         |
| (Wyville Thomson, 1877)                       |                                   |
| <i>A. convexa</i> (Lyman, 1878)               | <i>A. bullata convexa</i>         |
| <i>A. vitjazi</i> Litvinova, 1971             | <i>A. bullata vitjazi</i>         |
| (iv) Ophiolepidinae                           |                                   |
| CURRENT USAGE                                 | PROPOSED CHANGE                   |
| <i>Ophiosphalma planum</i> (Lyman, 1878)      | <i>O. armigerum</i> (Lyman, 1878) |

### 3. New species described

#### Ophiuridae

- (i) *Ophiura scomba*
- (ii) *Ophiambix devaneyi*

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